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Teaching Professional Qualities

By N. W. DOUGHERTY

First Vice President of the Society

Charles F. Scott, former President of The Society for the Promotion of Engineering Education, has been bombarding engineering teachers with Wickenden's "Second Mile—A Resurvey." In doing this he has performed a real service to the profession and at the same time placed engineering teachers in a new current of instruction which may lead them to a better understanding of professional goals. Dean Crawford promoted a conference at Cincinnati which produced enough discussion to warrant the assumption of a real interest in professional topics.

We suggest that engineering teachers undertake to give instruction in professional qualities. By this we mean instruction which will lead students to the conclusion that they are preparing for entrance into an exacting profession and that on entry they assume duties and obligations which are not required of non-professional practitioners. How can these things be? Are not the obligations of good workmanship imposed on all workmen? Certainly satisfactory performance is required of all, but the professional must be the judge of the excellence of his own performance. Only professionals can judge the correctness of the work done by professionals. (This may seem a little dogmatic to an engineer who criticizes the performance of English and Physics professors.)

What are the qualities? Dr. Doherty in his presidential address at Cincinnati named some of them:

1. That its members shall have acquired an organized body of higher learning.
2. That they serve their clientele by the application of that learning.
3. That they control a system of professional education and strive for its improvement.
4. That they share a common purpose and method of service and a common code of conduct with respect to each other and to their clientele.
5. That they serve their country by expert counsel in their fields, by participating as civic leaders in community enterprises, and by forming intelligent judgments on political issues and then actively supporting them.

We would add a sixth. That they must assume individual responsibilities for their acts, and in many cases this responsibility leads to a relation of confidence to the client or to the public or to the client and the public.

Can these things be taught? Our answer is yes, but only by those who possess them and then by precept and example as well as by classroom assignment and report. Obviously staff members must possess professional attitudes and qualities to create the favorable climate in which they may grow.

Before any group may say it is professional it must have a history and a tradition. No one would contend that engineers fail in this respect. Their failure has been in the readable record of their achievements. Pride in ancestry, greatness in achievement, and hope for a future are essential parts of the climate for professional growth.

Engineering history may be written and taught to students both as formal assignments and as inspirational reading. The profession may need "a good five cent cigar" but it further needs a good readable history. It needs more; it needs a series of biographies of eminent engineers who have lived since the day of Samuel Smiles. Here is a task designed for the abilities of someone who has the spirit of engineering and a knowledge of men and their achievements.

A Committee of Engineers' Council for Professional Development is proposing a uniform code of ethics. Some day the code will be written. Until that day students should be taught the codes of the several societies. They should be made to understand the relations of engineers to each other, to the public, to their employees, and a new section should be added stating the relation of employer to employee.

Most of our instruction is in the areas suggested by Dr. Doherty's first three points. To be an engineer the practitioner must have the rudiments of knowledge suggested by the Committee on Aims and Scope of Engineering Curricula and restated by the Committee on Engineering Education after the war.

The Committee has more than hinted that professional qualities are a vital part of the young engineer's equipment.

> Consciousness of the engineering fraternity as a functional group in society engaged in constructive work of a common nature, using common method of thought, and inheriting common obligations.
>
> Appreciation of the heritage of knowledge and art, of standards of performance, and of the traditions of group action from professional development.
>
> Recognition of the confidential relationship between agent and client, of the principles of fairplay between colleagues, and also encompassing social duty to the public adequately and honestly given.
>
> Loyalty to the principles of professional ethics not alone according to the canons in which they have been formulated but according to the spirit in which they have been conceived.
>
> Obligation to serve the profession in the advancement of its science, technology and art, and also in the discharge of its broad social duty.

Group activity is an essential part of the professional life. Early in the school program students should begin their group contacts. They should take

an active part in student branches where they may discuss the things suggested in this paper. By practice they will learn how to use the democratic process of open assembly to arrive at group conclusions which may be better than the findings of any individual.

We admit that most of the education in professional qualities will come by contact and contagion, but we urge that teachers become conscious of their professional possibilities and thus create an atmosphere and a climate where these things may grow. Formally we should try to sow the seed which may grow into a useful part of the profession. It may grow like the Kingdom: "First the grain, then the ear, then the full grown corn in the ear."

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The Post-War Challenge to Engineering Education*

By H. S. ROGERS, President of the Society

One who desires to make any study or survey of educational plans for, or of institutional problems of post-war engineering education cannot get far from the basic outline of the problems presented in May of this year in the report of the Committee on Engineering Education After the War, nor from the work of the divisional committees of our national society. It was the purpose of the post-war committee to study both the urgent and immediate problems of engineering education and the longer range problems of educational principles and practices.

Most of the matters of more immediate concern are of primary interest to administrative officers and faculty committees. They are found in such areas as secondary school training, selective practices for admissions, evaluation of junior college programs, physical education, and special guidance and training for veterans entering or returning to college. The problems within some of these groups are perennial problems of faculty committees. Various groups or committees of our Society also are giving particular attention to each of these fields. Problems such as those presented by the status of secondary school training and the merits of selective admissions are under constant study of our standing committees. Other matters such as the physical conditioning of students and the determination of academic credits for military programs are being studied by agencies outside of our engineering faculties. Such problems as those presented by veterans' education require some organized approach for the purpose of securing information and formulating plans and procedures. The Administrative Division of the Society is giving its active and constant attention to these matters.

The long range development and improvement of engineering education, on the other hand, are the major common task and common responsibility of our engineering faculties. Regarding long range matters the Committee on Engineering Education After the War limited its report and recommendations to the basic areas of engineering education, such as scientific-technological and humanistic-social, and to the fundamental principles involved. It was the hope of the Committee and the expectation of the Council of the Society that the report would stimulate experimentation both in curricula planning and in instructional methods, that the opportunities of the post-war adjustment period would be utilized to the fullest for the inauguration of those plans and procedures which give promise of permanent and general value, and that the results of such experimentation would be presented to the Society through its regional and national meetings.

* Presented at the Fall Meeting of the New England Section, S.P.E.E., Harvard University, October 7, 1944.

A consideration of the needs and opportunities for improvement and development can be approached most readily under these general headings of scientific-technological subjects and humanistic-social studies and under the topics, graduate study and research. The first of these areas is served by the various divisions and committees of our Society. We have just organized a Division of Humanistic-Social Studies to serve the second. The Committee on Graduate Programs is of recent origin but bids fair to develop into a Graduate Division at an early date and the Committee on Research is coincident with the officers and Executive Committee of the Engineering College Research Association. It is through these divisions and committees, and through the sections and branches, that the Society may focus group thought and action upon post-war problems and contribute to progress in engineering education.

In its report on the scientific-technological stem, the Committee placed major emphasis upon methods of engineering thought, discipline in engineering habits of work, and indoctrination in the ideals and ethics of the engineering profession. The problems of these areas are a perennial challenge to engineering educators and occupy much of our attention in society meetings.

Engineering Thought

A general understanding of the nature of engineering thought as outlined in the report would go far toward improving our methods of instruction and lead to the development of greater ability and power on the part of engineering students in the use of these thought processes. Far too often for the welfare of engineering education are student and instructor alike oblivious to the generic nature of principles underlying working formulas which have been developed for facility in the solution of more or less standard problems.

We need not only a clearer and more unified understanding of engineering thought operations but also a more critical and comparative study of methods for developing facility in the use of such processes. The report presents an elementary discussion of the tools of engineering thought and briefly suggests teaching procedures for its development. There is a great opportunity in the sections and branches for an exchange of information and views upon teaching methods which emphasize the general nature of engineering thought and the development of skill, resourcefulness and judgment in its use.

After the last war a number of institutions developed courses in engineering problems, some at the freshman level and others at higher levels. It was the purpose of these courses to drill students in the engineering method and major emphasis was placed upon engineering analysis rather than upon subject matter. Some of these courses have developed with such strength that they have influenced the student's entire training; others have been less successful. Recently several institutions have developed engineering analysis as a disciplinary course at the upper division and graduate levels. There are various advantages that are inherent in the teaching of such courses at any level and undoubtedly the ability of students can be improved by such a concentration upon thought processes in contra-distinction to subject matter. On the other hand, were there a common understanding of the nature of en-

gineering thought processes and were the practice of emphasizing its nature developed in all engineering courses, the results in the training of students would greatly surpass those to which we are presently accustomed.

Discipline in Engineering Habits

Engineers look forward to occupations in industry or in public works where certain attitudes toward and habits of work are prevalent. Industry, accuracy, thoroughness, neatness and initiative are the traits most frequently emphasized and highly prized by industry. Such emphasis is naturally a part of the broader concept of efficiency, economy and conservation, which characterizes productive enterprise. It may well be that the doctor, the lawyer or the preacher might find it desirable to emphasize other traits, but in the engineer these are harmonius with the general aims of industrial efficiency. As a characteristic feature of professional competency, discipline in such virtues should be incorporated in the engineer's training. The engineering schools have a reputation for demanding industry and accuracy beyond that demanded by most other schools. We could go still further in our demands for discipline in system, order and neatness, not only upon our students but upon our staffs.

Indoctrination in Engineering Ideals

During recent years, largely as a result of the work of the E.C.P.D., our engineering societies have become more conscious of their status as functional groups within the social structure and have recognized more clearly the significance of professional ethics and ideals. The Societies and the Registration Boards have both promulgated standards of qualification and of conduct and E.C.P.D. has engaged in a program for developing professional consciousness. We of the S.P.E.E. have participated in this movement through our Committee on the Principles of Engineering Ethics and the Coördinate Committees in Personal Development. For the coming year these latter have been grouped into one Committee on Professional Development which will articulate its work with the Committee on Selection and Guidance.

The approach to professional indoctrination can be more directly made through the student branches and founder societies than through the classroom. The influence of the instructor's ideals and ethics in an indirect manner is probably, however, more significant than formal discussions in student chapters. Nevertheless a conscientious program of professional indoctrination can contribute much to the next generation of practicing engineers.

Curricula

It would appear that our undergraduate curricula are more or less standardized as a result of their emphasis upon the unchanging principles of engineering science rather than upon the changing standards of engineering practice and furthermore as a result of accreditation by the E.C.P.D. The progress of new applications during the war, nevertheless, will probably influence certain of our curricula. Just as the development of communications effected changes in electrical engineering curricula built largely around power, so will the developments of ultra-high-frequency effect further changes in present curricula. While the influence of electronics may be

more significant in electrical engineering than any single development in other fields, it is certain that, along with high frequency, the other relatives such as high pressures, high temperature, high speeds, high polymers and high flying will have their effect upon the applications introduced into undergraduate curricula. They will affect graduate study, however, in a greater measure.

The great need of industry, expanding under war production, for men who, together with a mastery of the principles of engineering and the power constructively to apply them, possess also a knowledge of materials, plant layout, manufacturing processes, mass production methods and controls has brought the fields of operation and management into bolder relief as a challenge to engineering education. Modern industry with its specialized use of materials, with its diversified use of power and transmission systems, with its highly developed machine tools and processes, with its planning and scheduling of production and all the techniques of control of material processes, of costs and of labor operations, has developed a technology which has been analyzed and rationalized in a basic and thoroughly engineering manner.

Some of the practices and many of the techniques are amenable to classroom and laboratory instruction; some practices, operations and procedures are not. The practices in time and motion studies, in gaging, in scheduling and in other production controls as well as the procedures in cost analysis, and in estimating, are among those so rationally and so fundamentally developed that they have been integrated into engineering curricula in an elemental manner. The number of curricula which have been developed in the field of management or production are, however, still limited as related to the demand for men from American industry.

While a certain mastery of engineering fundamentals and a discipline in engineering methods of thought are the very foundation and backbone of any program of engineering education and are likewise essential to the understanding of modern industry, it nevertheless is desirable that those engineering schools, which have the resources of equipment and personnel, develop curricula which will in part meet the needs of industry in the production and management fields and offer an outlet for the interests and abilities of many post-war students. The instructional divisions of our society may well give more attention to this matter.

Graduate Study

Perhaps the field of engineering education which will be influenced most by war experience is that beyond the undergraduate program in the graduate and post-collegiate years. The expansion of research and the development of new techniques particularly in chemical, electrical and aeronautical engineering have surpassed any experience in history. While much of the development has been in fields of application rather than in basic theory, the technology involved has been upon such a high level that graduate work is becoming increasingly more necessary and special in-service courses for engineers in industry more desirable. These developments will bring more formal course organization into the programs at the master's level and will stimulate the expansion of work of a more fundamental nature at the doctoral level.

One of the most significant developments in engineering education in recent years has occurred in the field of graduate evening study. Where strong programs have been offered in industrial areas, registration has grown by leaps and bounds. Our Committee on Graduate Programs is actively following all developments in this field.

Research

There has been a school of thought among some industrialists that held engineering colleges were not situated or prepared successfully to pursue research in any but the abstract fields of scientific knowledge. Experience in war-time has, however, demonstrated that many institutions have the personnel and facilities to make substantial, even great, contributions to the development of new instruments of warfare. The achievements which have been made are reason for a growing confidence in the resourcefulness of engineering schools which should encourage greater coöperation between industry and the schools in the post-war period. The extent of such research will obviously decline with the cancellation of government contracts but that industrial contracts will go forward in increasing volume seems equally certain. The E.C.R.A. is a potent force in such developments.

Humanistic-Social Studies

The 1940 report on Aims and Scope of Engineering Curricula focused attention on the objectives of the humanistic-social studies in engineering curricula as a unit and phrased these objectives in such broad terms as the "Understanding of the evolution of the social organization within which we live and of the influence of science and engineering on its development," and the "Development of moral, ethical, and social concepts essential to a satisfying personal philosophy, to a career consistent with the public welfare, and to a sound professional attitude." It made no attempt, however, to specify the means by which such objectives could be attained. The report of the Committee on Engineering Education After the War went further in a prescription of methods of organization and of conditions under which progress toward such objectives might be made. Among these are such recommendations as "Establish responsibility for planning and coördination," "Formulate the results as explicitly as possible," "Allot time in more advanced years as generously as possible," etc. It is recognized, however, that many difficulties must be overcome before such recommendations can be established.

Institutions of the unitary type can proceed in the manner prescribed much more readily than engineering schools in a university system. Some of these, such as the Massachusetts and Carnegie Institutes of Technology, have already developed integrated programs in this field.

The breadth of objectives, the scope of studies, the diversity of faculty views and backgrounds, and the variety of activities which must be brought to bear upon a unified program give reason to conclude that developments may be widely different. Common to all such programs, however, are certain basic judgments of value and factors of motivation.

The neutral detachment so desirable in science will not be found nor will it suffice in the humanities and social studies. The "evolution of the social organization within which we live" may be understood through a genetic

or historical study, but a belief in democracy, a commitment of oneself to professional ideals and the "development of moral, ethical and social concepts essential to a satisfying personal philosophy" require the cultivation of a sense of values. Qualitative judgments of value have their foundation not alone in philosophical analysis but are conditioned more particularly by attitudes, loyalties and beliefs acquired variously in the course of life. How to refine judgments of value and motivate men to behave in accord with them are among the most perplexing and obscure problems of all education.

The classical tradition had its origin in the aim of the great philosophers to urge free men to an understanding of the good life. In the course of its history, it has developed into a didactic system which still dominates teaching in the humanistic-social field. In contra-distinction to the book learning resulting from such teaching, engineers expect that out of the humanistic-social studies and from the experiences of life situations we may improve the student's ability to question, to consider, to seek evidence, to weigh, to judge, to make discriminate choices between good and evil, between right and wrong, between beauty and ugliness, and to act as a free and responsible individual in society.

It may rightly be expected that achievement of the formulated objectives will be a long and arduous task. The beginning of experiments in this field is encouraging. The new division of Humanistic-Social Studies of S.P.E.E. is tackling this problem with vision and courage.

In conclusion, it is obvious that I have made no attempt to be a clairvoyant and picture the nature and extent of post-war developments in engineering education. On the other hand, I have endeavored to point out the avenues which offer a great challenge to growth and progress and the resources within our Society and related agencies which are available for and operative in the promotion of progress.

Scientific and educational institutions are not assembled as manufacturing companies may be, but develop through a slow biological process of internal growth. Even when objectives are clearly visioned, progress can be made only through the selection of materials, the preparation of programs and the development of teachers. The war has accelerated growth in certain areas and magnified the need in others. The engineering schools of the country were never more realistically conscious of their problems, objectives and needs than at present. They have many difficulties of facilities and personnel to overcome, but they have also a great confidence and faith that they will and can go forward at an accelerated pace when hostilities are over and students in large numbers and faculties broadened by experience return to their halls.

Technical Institutes

Plans are underway for the accrediting of the curricula of technical institutes by the Engineers' Council for Professional Development, according to an announcement made by H. P. Hammond, dean, School of Engineering, The Pennsylvania State College, who is chairman of a Subcommittee on Technical Institute Programs of E.C.P.D.

"The general purpose of the accrediting program," Dean Hammond said, "is to raise the standards of instruction in the field of technical education intermediate between the engineering college on the one hand and secondary and vocational schools on the other, and to place this field of education on a basis of strength and usefulness comparable to the position it holds in other industrial nations. It is expected by this means to enhance the general status of technical and engineering education as a whole."

Dean Hammond announced the personnel of the committee as follows: C. W. Beese, of Purdue University; George W. Case, of the U. S. Office of Education; John T. Faig, of the Ohio Mechanics Institute; L. J. Fletcher, of the Caterpillar Tractor Company; E. H. Rietzke, National Council of Technical Schools; and B. M. Woods, University of California.

The Engineers' Council for Professional Development, organized in 1932, is made up of three representatives of each of the following organizations: The American Society of Civil Engineers, the American Institute of Mining and Metallurgical Engineers, the American Society of Mechanical Engineers, the American Institute of Electrical Engineers, the American Institute of Chemical Engineers, the Society for the Promotion of Engineering Education, the National Council of State Boards of Engineering Examiners, and the Engineering Institute of Canada.

The work of the Council is carried on by four major committees on student selection and guidance, engineering schools, professional training, and professional recognition which cover all phases of the engineer's career from the time he makes up his mind to enter an engineering college until he has acquired full recognition in the practice of his profession.

Accreditation of curricula of engineering schools was undertaken by the Council many years ago and has resulted in the publication of lists of accredited curricula which are available for public reference. As only curricula leading to degrees in engineering were accredited by E.C.P.D., and the benefits of accreditation have been so marked, E.C.P.D. was asked to undertake a similar program for curricula of schools of the technical institute type. Authorization of E.C.P.D. to embark on such a program was recently voted by the eight organizations which comprise the Council. The Subcommittee on Technical Institute Programs was therefore organized to undertake the development of the accrediting program.

At the organization meeting of the subcommittee held in Chicago, Ill., Oc-

tober 22, 1944, a statement of the basis for accrediting technical institute curricula was adopted. This statement lists the general requirements which accredited curricula must satisfy, such as the length of curricula, requirements for admission, the nature of the curricula, the method of instruction, the training, experience and number of the teaching staff, the type, financial stability, and achievement of the institution in which the curricula are offered, and the adequacy of physical facilities.

Principles and procedures to be followed by the subcommittee in its work are the following:

"1. Individual curricula are accredited.

"2. Rigid standards as a basis for accrediting are avoided in order to prevent imposed uniformity and to encourage educational experimentation.

"3. Curricula are appraised on invitation of the institution offering them.

"4. Curricula are accredited on the basis of both qualitative and quantitative criteria which are evaluated through visits of inspection by a committee or committees representing E.C.P.D. and through data secured from catalogues, other publications, and questionnaires.

The subcommittee's statement makes it clear that any lists it publishes will include only curricula that have been accredited. It is planned that accrediting may be extended for a period of unlimited duration or may be made on a provisional basis for a limited period with reappraisal at the end of that period. This procedure is the same as that which has been satisfactorily followed by the E.C.P.D. in the accrediting of engineering curricula.

In addition to the accrediting program, but only upon request of recognized officials of an institution, informal advice will be given on matters such as changes in educational policy, organization, curricula, personnel, and physical facilities.

It is further planned to reinspect curricula at intervals of three to five years in order to maintain the accredited list on a dependable and up-to-date basis.

International Relations Involving the Training of Students from Foreign Lands*

By S. S. STEINBERG

Dean, College of Engineering, University of Maryland

The present world war, more than any other event in our history, has caused us as a nation to take stock of our relations with the world at large. For the first time we have become acutely conscious that the whole world is a unit and that a great change in any nation may have important effects on our own domestic affairs. Better international understanding can come about only through greater knowledge of the cultures of other peoples, and the means of better understanding are through education and by actual contact with the representatives of other lands.

The present war has proved the definite need for expansion of our formerly meager efforts in the promotion of genuine international goodwill. It has become evident that greater attention should be given to the training of foreign students and the interchange of professors between educational institutions.

Status of Training

The following recent information, gathered from many governmental and private sources, gives the present status of the training of foreign students in this country. While the emphasis will be upon the training of engineering students, other examples will be cited in order that an appreciation may be gained of the scope of training of students from other lands.

Statistics on foreign students in the United States show that the number has been increasing during recent years to a maximum of more than 8,000 for the academic year 1942–43. At the present time, the enrollment from all foreign countries is about 7,000. The present enrollment of students from Latin America is about 3,000. One-fourth of all foreign students, or about 1,700, are in engineering and likewise about one-fourth, or less than 700, of the Latin Americans are engineering students. The foreign students in this country are located in about 250 colleges and universities.

The Institute of International Education, founded in 1919 after the close of World War I, has since then been the usual agency of the colleges and universities of this country in carrying on their international cultural relations with European countries. In 1938 the Institute was chosen by the State Department and the Coördinator of Inter-American Affairs to be their instrument in realizing some of their cultural programs with the Latin American countries, especially in the exchange of students and teachers.

* Presented at Meeting of Division of Administrative Officers, Society for the Promotion of Engineering Education, at Chicago, Ill., October 23, 1944.

The wartime entrance of the United States Government into the inter-American student field has proved the greatest stimulus for the movement. During the last pre-war academic year 1938–39, there were only 35 Latin American students in the United States on full-year fellowships administered by the Institute of International Education. In the year 1943–44, 370 Latin American students held fellowships in the United States under the auspices of the Institute and 53 United States graduate students on fellowships in Latin American universities. These students were chiefly in engineering, agriculture, public administration, social service, journalism and education.

Only one European exchange has been active during World War II and that is with little neutral Switzerland. This is now virtually a "one-way exchange" inasmuch as students from the United States have not been able to secure passports to go to Europe since September, 1939, although fellowships are available to them in Switzerland.

The expanded program of Latin American students in the United States has caused the Institute, whose headquarters are in New York, to open a Washington Bureau in September, 1943, to facilitate contacts with the United States government agencies working on international educational matters.

Latin American Student Program

The first government assistance made available to Latin American students was under the terms of an inter-American agreement signed at a meeting in Buenos Aires in 1936 and known as the Buenos Aires Convention. This agreement provides for the exchange by each of the 21 American republics of two graduate students annually and one or more professors every two years with each of the other governments. Thus far only 16 of the nations have ratified this convention. To the end of 1943, the United States received 63 convention students and has sent abroad 29 American students. The government nominating a student pays his traveling expenses and the government receiving the student pays his tuition, board, and lodging. In December, 1942, the appointment of United States students to study abroad was suspended for the duration of the war.

Following are some of the recent Latin American training projects that are of interest:

Iowa State College arranged a special free course in climatology for six visiting students from the other American republics. These students received maintenance grants from the United States Government, but paid their own traveling expenses.

The University of Michigan awarded 20 tuition scholarships to students of forestry from the other countries of this hemisphere.

A group of 20 dentists, one from each of the other American republics, came to the United States in 1943 under the auspices of the American Dental Association and the Kellogg Foundation. The Foundation paid all expenses of the group during a special post-graduate course in dentistry at the University of Michigan with additional work in Chicago and Philadelphia. The Department of State provided traveling expenses from the home countries to the United States and return.

Pan-American Airways has awarded 20 round-trip air tickets to students each year, one from each of the 20 Latin American republics.

Reader's Digest has given scholar-

ships to doctors and nurses throughout the hemisphere for the study in this country of infantile paralysis.

In 1943, the Government of Peru appropriated $50,000 for sending students to the United States.

Under a project initiated by the Bolivarian Society of the United States, named in honor of Simon Bolivar, the great liberator of South America, 26 Latin American students came to the United States in 1943. Their own governments paid their traveling expenses, the United States Government took care of their maintenance, and tuition scholarships were provided by American universities.

In addition, many civic groups, fraternal societies, service organizations, women's federations, both state and national, also provide funds to supplement partial scholarships for foreign students.

Before the present war the Turkish government had sent a large number of students in engineering to Germany and Great Britain. When the war broke out and aerial bombing took place in England and afterward in Germany, the Turkish government decided to remove these students to the United States. As a result there are now, for example, at the California Institute of Technology eight Turkish students in mechanical engineering.

When Japan made its attack on Pearl Harbor there were more than 1,500 Chinese students in the United States, many of whom were studying engineering. None of them could return home and few were able to receive funds from home. Under the circumstances our State Department, together with the Chinese Government and the universities, supplied financial aid to enable these students to finish their studies. Upon completion of their courses the students were engaged by United States industrial organizations and United States Government Departments to enable them to gain practical experience.

Training in Industry

In addition to professional engineering training, a recent development has enabled large numbers of foreign students to secure practical technical training in American industry through Inter-American trade scholarships established by the Coördinator of Inter-American Affairs. These scholarships enable young men, between the ages of 18 and 28, to come to the United States for one or two years of practical training. The United States Government pays round-trip traveling expenses and a maintenance allowance during a brief period of orientation. The companies which provide training then pay all expenses of the trainee during the period of instruction.

At the close of 1943, 90 men had been placed under this program in oil refineries, mines, rubber plants, telephone companies and other establishments.

Under a similar program set up by the Department of Agriculture, 24 men were assigned to field parties in the Soil Conservation Service on soil-engineering problems, and 35 additional men were placed in agricultural extension work. Similarly, the Rural Electrification Administration provided field experience for 18 men.

The largest single project of this type was that for aviation technicians from the other American republics established by the Civil Aeronautics Administration. A total of 609 pilots, engineers and mechanics were trained by this agency during the period 1941-43. At the close of 1943, applications

had been approved for another class of 138 men. More than $3,800,000 was made available for this series of aviation classes, from which at least 120 graduates are now reported employed by airlines and flight-instruction schools throughout Central and South America. Nearly all the Brazilian graduates entered the Brazilian air force.

The United States Weather Bureau, using funds from the Coördinator of Inter-American Affairs and the Defense Supplies Corporation, organized a six months' training course in 1943 for meteorologists and climatologists from all the other American republics. The course was held in Medillin, Colombia, and was attended by 200 men. When the class was completed, the Department of State gave fellowships to 29 of the best students to come to the United States for 15 months of additional study in universities and in Government weather stations.

More than 300 sanitary engineers, physicians and other public health specialists from Latin America were receiving or had completed advanced training in the United States in the 12 months ended June, 1944, under grants from the Institute of Inter-American Affairs.

At the request of the Chinese Government a group of Chinese college graduates are being trained by the U. S. Soil Conservation Service in the making of composite maps from aerial photographs. It is the hope of the Chinese Government that a new land survey of China can be undertaken later through aerial photographs.

About 300 Chinese students have been placed during the war in positions in American industry or commerce where they can earn their own expenses and receive practical training in their fields of study. These men are with 10 different aircraft companies, 3 electrical manufacturers, 2 locomotive works, 2 steel companies, and a score of other engineering and scientific firms.

A group of 8 Chinese civil engineers recently arrived in this country for study of flood control and irrigation in connection with the United Nations Relief and Rehabilitation Administration program in China.

Another group of 35 Chinese industrial engineers have been in this country for the past 18 months in training with the Tennessee Valley Authority and other agencies.

These training projects are all indications of China's awareness of the importance of training engineering and industrial personnel for her post-war reconstruction period.

Conclusion

Looking toward the future, there is no doubt that after peace is restored the number of foreign students who will come to this country, particularly for engineering education, will be many times the number that have come in the past. Our sympathetic handling of these students will render a service not only to the country to which they return but also ultimately to the cause of international goodwill.

The Accrediting of ASTP, ESMWT, V-12, and Army Institute Credits*

By A. J. BRUMBAUGH

Vice President, American Council on Education

It became apparent in the early stages of the present war that the educational institutions would be confronted, as they were in World War I, with the problem of granting credit on some basis for educational experience gained in the armed forces. To avoid their previous error of granting specious credit and bogus diplomas, educational associations and institutions joined in declarations against giving blanket credit for military service. These declarations generally took the form of an endorsement of "Sound Educational Credit for Military Experience," issued by the American Council on Education. As the war progressed it became increasingly clear that a positive plan of evaluating educational experience gained in the armed forces was called for because education was to play a large part in meeting the demands of war, and because extensive provisions were made for men and women in the services to continue their education. Gradually the following basic principles seem to have evolved:

(1) That secondary and higher educational institutions must recognize genuine educational achievement on the part of members of the armed forces, regardless of the plan or auspices under which the education was gained.

(2) That the educational institutions must assume the responsibility for determining what educational achievement shall be recognized and how that achievement shall be measured. This principle of institutional autonomy is part of our American educational tradition that must be preserved.

(3) That the conventional pattern of semester hour or course credits based on time units and instructors' marks is not applicable to the evaluation of educational experience gained in the armed forces. Therefore, new plans of evaluation must be developed.

(4) That there must be some consistency in the evaluative procedures employed to avoid confusion among the institutions and to provide equitable treatment for the veterans.

(5) That this problem must be approached coöperatively by the institutions.

The complexity and magnitude of the problem with which both secondary and higher education are confronted become immediately apparent when we consider the wide variety of educational experience that veterans will have had; the approximate numbers that will have had these various types of experiences; and certain inevitable complications that arise due to the exigiencies of war.

* Presented at meeting of New England Section, Harvard University, Oct. 7, 1944.

The in-service educational experiences of members of the armed forces who plan to resume their studies in the secondary schools or in the colleges, universities, and professional schools are of four types. First, the various educational programs given entirely or largely under the auspices of the colleges and universities. The ASTP program provided instruction in nearly 50 different curricula. In some instances these curricula reflected only minor differences in content and organization, but it is safe to say that instruction was offered in at least ten or a dozen different subject matter areas. The Navy V–12 program, similar in some respects to the ASTP, likewise provided instruction in 10 or more areas of technical, professional, or pre-professional education. To these rather comprehensive formally organized programs must be added the training of cadets and the Civil Aeronautics Authority Program of the Army Air Forces, and the Meteorology programs offered in a comparatively small number of institutions. Somewhat different in character, but also given under the auspices of educational institutions are the ESMWT courses designed to provide specialized training of a practical nature for immediate employment or for the upgrading of individuals on jobs.

A second type of educational experience is that provided through the several educational agencies within the armed forces; for example, the Armed Forces Institute, the Educational Services Section of the Navy, the Marine Corps Institute, and the Coast Guard Institute. The programs of these agencies include correspondence courses, self-teaching courses, and informal off-duty classes. These programs will probably be extended to include formal instruction in foreign universities and educational centers abroad during the period of demobilization and occupation.

Third, consideration must be given to the informal learning experience derived from extensive travel, contacts with people and cultures of foreign countries, and independent reading and study.

The fourth type of education is that provided by the formal training programs in the various branches of the armed forces. There are hundreds of these programs, each directed to the development of specialized types of abilities and skills essential to the effective performance of specified duties in the various branches of the services.

Civilians who are engaged in industries and other activities related to the war will also have had various kinds of training and experience which in some instances are related to the educational programs of schools and colleges.

There is no adequate basis at present upon which to predict the number of individuals who will request an evaluation of their educational experience in order to determine their status in secondary school or college. It appears, however, that in the aggregate at least 3 million members of the armed forces and individuals engaged in civilian war activities will have participated in some form of organized education other than the regular military training programs. Even though the percentage of individuals who may wish to resume some type of formal education after the war should be relatively small, the number of individuals whose experience must be evaluated by educational institutions will be impressively large.

The problem of making these evalua-

tions is complicated by the fact that:

(1) The content of some of the programs changed from time to time;

(2) In some instances students were unable to complete the programs in which they were enrolled;

(3) Educational standards have had to be adjusted to take cognizance of very heavy schedules with little time for study outside of class sessions;

(4) Some students were inadequately prepared for the programs in which they were enrolled;

(5) The physical education requirements in some instances were so demanding that students frequently were too fatigued to do their best in their academic programs;

(6) Faculty members in some institutions were withdrawn from military service requiring hasty replacements by less competent instructors.

It is generally agreed that in the case of the ASTP, Navy V–12, Army Air Forces, Meteorology, and other programs of a similar nature, conducted under the direct auspices of educational institutions, each institution shall evaluate and record these courses in the same way that it evaluates and records other courses given under its administration. There will undoubtedly be variations among institutions in the credit value assigned to these courses.* Will these variations be a source of embarrassment or difficulty in the exchange of credits? It is my opinion that such variations are not likely to be greater than those that now obtain relative to non-military courses. The problem will also arise of fitting these courses into a pattern of general or pre-professional education that is regarded prerequisite to specialization.

Engineering colleges generally have made less provision in their curricula for general education than have the liberal arts colleges. The engineering colleges will therefore be confronted with the dual problem of determining the nature of the non-technical education that will be acceptable in terms of their objectives and the needs of their students, and of evaluating the more distinctly technical forms of education in terms of prerequisites for advanced engineering courses. The liberal arts colleges, on the other hand, have in most cases defined or are in the process of defining their general education programs. They are confronted more especially with the problems of deciding how much and what kind of technical training can be accepted to apply either at the level of general education or in a field of specialization.

Institutions are likely to be under considerable pressure during the next few years to grant credit for ESMWT courses even though it is generally agreed now that because of their specialized character these courses do not entitle those who took them to college credit. The only safe procedure on the part of institutions that are inclined to give such requests any consideration is to depend on well constructed examinations whereby individuals may demonstrate competence that corresponds to achievements in their regular educational programs. It is very unlikely that many individuals will be able to validate educational credit for ESMWT courses on the basis of such examinations.

Three important questions will also arise regarding correspondence courses given either by universities affiliated

* Bulletin No. 69, *Higher Education and National Defense*, July 26, 1944, issued by the American Council on Education, contains recommendations made by the Committee on Accrediting Procedures.

with the USAFI or under the direct auspices of the Institute or of other branches of the armed forces. The first is the extent to which institutions will be willing to accept credit for correspondence courses in fulfillment of requirements for degrees.

The second pertains to the procedures that institutions will employ to evaluate correspondence work when members of the armed forces have done a substantial amount of work in correspondence courses, but have not taken the end-of-course examinations. If I may venture to suggest an answer to this question, it is: Either use the examinations in specific subjects prepared by the USAFI for civilian use,* or construct appropriate examinations for this purpose.

The third question relates to graduate credit for correspondence work. Data supplied to the Committee on Accrediting Procedures of the American Council on Education by the Association of American Universities indicate that graduate schools generally are not inclined to allow credit for correspondence courses. The Committee on Accrediting Procedures, in Bulletin No. 69 already referred to, has made the following statement on this point:

> In the light of present conditions, the Committee believes that institutions may wish to re-examine their policies with respect to this matter. If graduate credit for correspondence and independent study is contemplated, institutions should safeguard their standards by giving examinations to evaluate the students' achievement.

The more crucial problem, however, is the evaluation of educational development resulting from off-duty study, independent reading, and travel. In this area the General Educational Development Examination of the USAFI provides the most valid measure of achievement that is available. The norms for this examination provide comparable data on both a national and a regional basis. Here again the policies of many institutions relating to the classification of students will have to be revised. Suppose that a student who has not completed high school achieves a standing in the General Educational Development Examination equivalent to that of a college freshman or sophomore. What standing are the colleges and universities willing to give this student? Suppose further that he is given sophomore status; how will the institution enter on its records the equivalents of his freshman work? The case may be more complicated, however, if the student's achievement is at the freshman or sophomore level in certain divisions of the examination, but at the subfreshman level in other divisions. There is likely to be a sufficient number of students in this latter category, particularly in the larger colleges and universities, to require these institutions to offer instruction below the freshman level.

There will also appear many cases in which individuals have not taken the General Educational Development Examination prior to their separation from the armed forces. In such instances institutions must decide whether they will use the special forms of the USAFI General Educational Development Examination prepared for civilian use and distributed by the Coöperative Test Service of the American Council on Education; whether they will construct their own examinations; or

* These examinations may be secured from the Coöperative Test Service, 15 Amsterdam Avenue, New York, N. Y.

whether they will completely ignore the matter of educational achievement gained on an informal basis. Because the examination staff of the Armed Forces Institute represents special competence in this field, and because the General Educational Development Examination is undoubtedly superior to examinations that can be constructed in most individual institutions, the preferred course of procedure would be to use the special forms of this examination.

There will also arise instances in which individuals will have gained special proficiency in specific subjects; for example, physics, mathematics, geography, and foreign language. This proficiency may result from a variety of experiences in the formal training programs of the armed forces, or again from informal study and experience. For the purpose of evaluating this type of educational achievement, the Armed Forces Institute has prepared, or is in the process of preparing, examinations in specific subject-matter fields. The questions of policy relating to achievement demonstrated by this examination are similar to those just discussed in connection with the General Educational Development Examination. Inasmuch as forms of these examinations will be available for civilian use, institutions will have at hand validated objective measures of competence in specific subject-matter fields for those individuals who did not take the examinations through the Armed Forces Institute while they were in service. These examinations are also available through the Coöperative Test Service.

The evaluation of educational achievement resulting from the formal training programs of the armed forces presents a special problem. With reference to credit for basic or recruit training, the following policy has been recommended by the Committee on Accrediting Procedures, and has been endorsed by the regional and national accrediting associations:

> Institutions should grant credit not to exceed a maximum of one-half semester to an individual who presents evidence of having completed successfully the basic training courses in the armed forces. This credit, if granted, should be assigned to hygiene, military science, physical education, or appropriate electives.

There are, however, hundreds of training programs, some of which contain elements of education related to the usual secondary or college curriculum. Some of these educational elements can be evaluated, as has already been indicated, by special subject-matter examinations. Certain phases of the training programs, however, do not lend themselves to an evaluation by the objective type of written examination. As a means of developing a consistent policy among institutions in evaluating the educational elements of these training programs, and in order to make available readily to institutions a description and analysis of the programs, nineteen regional and national educational associations including the Engineers' Council for Professional Development have underwritten a special project that is now well under way, under the auspices of the Committee on Accrediting Procedures of the American Council on Education.

Several facts regarding this cooperative study should be emphasized. The results of the study will be published in a "Guide to the Evaluation of Educational Experiences in the Armed Services." One section of the

Guide will be devoted to a description of the examinations prepared by the USAFI that are available through the Coöperative Test Service, a statement of the critical scores on these examinations, and the cost of the examinations. Moreover, in the descriptions of the training programs reference will be made to the use of examinations whenever appropriate forms are available.

Some of the training programs will, however, have in them types of educational experience that cannot be readily evaluated by examinations. To aid institutions in evaluating these programs the Guide will contain for each course a statement of the locations at which instruction was given, the length of the course, the objectives of the course, the plan of instruction, a description of the content, and recommendations concerning the credit within certain limits that might be allowed and the level, secondary or college, of the educational experience represented by the course.

These recommendations obviously are based on the false assumption that every individual derives the same educational value from the same training program. It must be recognized, however, that this same assumption underlies the method of transfer of credit currently employed by most institutions. It should be emphasized that the subjective evaluations of some of the training programs are to be regarded as supplementary to rather than a substitute for the examination technique.

As a means of improving the validity of the recommendation regarding credit in areas for which examinations are not available or cannot readily be constructed, a group of carefully selected consultants at both the secondary and the college level reviews critically both the analyses of the training programs and the recommendations that are prepared by the staff. Since the training programs embody chiefly materials of a technical and vocational nature, most of the consultants were chosen from these fields. Many of the training programs contain some materials related to engineering training. Therefore the group of consultants includes Frederic L. Bishop, Professor of Physics, the University of Pittsburgh; Huber O. Croft, Head of the Department of Mechanical Engineering, The State University of Iowa; and Olin J. Ferguson, Dean of the College of Engineering, The University of Nebraska.

It is not expected that the "Guide to the Evaluation of Educational Experiences in the Armed Services" will be made the basis of standardized practices in secondary schools and colleges. Obviously, the consultants in the various subject-matter fields and the staff that is preparing the materials cannot take into account the application of the recommendations either to specific institutions or individuals. Each institution will have to define its policies regarding the types of training programs that are related to its own objectives and degree requirements. Also, the credit that is allowed, if any, in accordance with the recommendations must be related to the individual's educational objectives. To adopt any other policy might be equivalent to granting "blanket credit," a policy which educational institutions at all levels disapprove. It is expected, however, that the Guide will be a means of maintaining some degree of consistency among the institutions in the amount of credit they may see fit to grant for certain training programs related to their own objectives and degree requirements.

From this analysis of the types of educational experience that ex-service personnel will present to the secondary schools and colleges, and of recent developments in plans for evaluation of these various types of experience, three conclusions deserve special emphasis:

(1) Each institution must develop and state clearly for the benefit of service men and women its policy for evaluating and granting credit for educational experience gained while in the armed services. This should be done immediately. In order that policies among institutions may not differ too widely or be in conflict, general statements of policy such as those published by the American Council on Education and the National Association of Secondary School Principals should be referred to because they represent the consensus of leading educators.

(2) Institutions should take advantage of the examinations that have been developed by the armed forces for the purpose of evaluating educational achievement.

(3) Institutions should also take advantage of the Guide to the Evaluation of Educational Experiences in the Armed Services in evaluating educational experience gained in the training programs of the armed services.

Engineering Education: Retrospect and Prospect*

By FRANK B. JEWETT
President, National Academy of Sciences

For nearly fifty years now I have been interested in the problems of *planned* education (much of it politely so called). Some of that interest for a period of twenty-five years was concerned with the administration of a public school system. For the most part, however, it has centered about college and university problems—primarily those involved in science and engineering education.

Of course earlier still I was *involved* with formal education, but I cannot now remember being much *interested* in it. In fact, such memories as I have seem to run to my distastes, particularly for grammar and writing as they were then taught. I saw no sense in the crazy scheme of making us dissect sentences and put the parts on a set of lines so that they looked like cars in a miniature railroad freight terminal. Equally distasteful was the enforced use of a sharp pen held rigidly, exactly according to rule, in a hand poised lightly on the tips of two fingers and moved with a free arm motion to make letters in a flowing Spencerian style.

I didn't want to be an old-fashioned bookkeeper or write like one. I wanted to use a stub pen and write like father, and I wanted to keep my wrist on the desk if I found it easier and form the letters by moving my fingers.

I am sure the grammar never taught me much about putting words in proper sequence to convey ideas clearly and both my friends and I know that I have long since overcome the horrid influence of Spencer's disciples in teachers' colleges and school book publishing houses.

In the initial years of this last half century, my interest was that of an innocent victim of the regimen then in vogue. Later for a few years it was that of a young instructor woefully ignorant of how best to do what he was supposed to do, and essentially a rebel against what seemed to him at the time, as it still does, a wasteful, inefficient method of fitting young men for their life work. Mainly, however, my interest has been in technical education at the college and graduate level and from the viewpoint of an outsider.

Partly this has been because of a natural interest in education and partly because for many years I have been a large customer for the product of our educational factories and so inclined to be critical of their manufacturing methods. Although much progress has been made in these methods since my student days, many of them, I think, are still far from meeting the specifications of efficient straight-line assembly.

Fortunately for me, applied science in the 1890's was not the enormously complex thing it is today. Even then, however, engineering courses and engineering instruction had for the most part lost intimate contact with the physics and chemistry and mathematics which gave them birth. True, ele-

*Presented at the inauguration of Homer L. Dodge as President of Norwich University, October 9, 1944.

mentary courses in these basic subjects were required of us but they gave us no glimpse whatever of the evolution that was going on in fundamental science. Nor were they designed to show us what engineering really was and its complete dependence on basic science.

To us, physics was as dead a subject as was the Latin which likewise we were compelled to take and which we made it a point to forget as soon as possible. Both seemed to us to be quite unrelated to engineering as we pictured it and merely intellectual hurdles which some one thought it good for us to surmount. Since Greek could be elected instead of Latin if we chose, I suspect that our guess was not far from the truth. Some boys did choose Greek because the professor was a delightful old gentleman with a sense of humor. They won out over the rest of us who elected Latin because they learned the Greek alphabet and so could recognize and pronounce the funny characters we were to encounter later in mathematical formulæ and on the fraternity pins.

As for English, while it was fun in a way and forced us to do some reading we might otherwise have missed, neither the English professor, his colleagues in engineering, nor we youngsters considered it really a necessary part of an engineering course. None of us had any thought that a properly designed course, properly given, would provide the engineer with his most powerful tool—ability to state clearly and concisely abstruse technical matters in words and sentences the laymen who run the world could understand.

Having cut adrift in all but token allegiance to their fundamental science forebears, the engineering faculties were for the most part inbred and concerned with the niceties of variant applications of long established laws. The courses were rigidly compartmentalized and as each new application attained to some prominence, a prescribed course in it was added to the curriculum of required subjects. It frequently later became the basis for a compartment of its own. The whole process was headed in the direction of knowing less and less about more and more.

Gradually by this process of addition engineering courses became a mighty hodge-podge of things poorly correlated with the result that such of the men as survived the gruelling ordeal and received a diploma had a little second-hand knowledge about a lot of things, but no really first-hand knowledge about anything. They could have taken prizes in a human patch-work quilt contest. Least of all did they sense the possibilities and dangers to their chosen profession which lay hidden in the gestating processes of fundamental science research.

Probably the worst things in the engineering education of those antediluvian days were the interminable hours, days and weeks spent in shop-work, drafting and a lot of repetitive operations such as the mechanical drawing and lettering in long descriptive geometry courses.

While it is true that engineering educators were struggling mightily to formulate proper courses, I still think that many of the gross deficiencies of the time and some which still persist evidence a lack of high class analytical thinking.

Most of us who were subjected to this trade school apprentice type of training lacked both the manual dexterity and the desire to become fine mechanics or skilled draftsmen. Not

one in a hundred of us was ever likely to use in his professional work such skill as he had acquired by main strength and awkwardness. We did need to know the principles of shop methods and practices; of how to read drawings and to sketch out our ideas sufficiently so that a skilled craftsman could put them in final form. We did not, however, need to waste a large part of our precious four years learning enough to enable us to pass some artificial test designed to prove us to be at least second-rate artisans.

The net result of all this, at its worst before the tide began to turn, was the offer of a multiplicity of courses leading to a multiplicity of named engineering degrees—some of them so narrowly specialized around limited techniques that men seldom or never followed them in after life. As for the students who took one of these courses, the curriculum was in a large number of cases a hodge-podge of poorly planned and poorly given fragmentary courses piled on to the limit of youthful human endurance.

There was little time for quiet thinking on the part of the student; less time for social amenities and frequently no provision or opportunity for them even had time been available. Always before him was the specter of the next day's greasy grind and in the distance that of the term's marks.

The net result was that the majority of students emerged with little if any broadening of their general intellectual horizons; with substantially no training in how to make their technical knowledge effective, and too frequently as uncultured men who nevertheless aspired to be classed as members of a learned profession.

The industries of the time were as much or more to blame for the state of affairs as the colleges and technical schools. They set the specifications for the raw material they wanted from the schools and generally they set them on the low level of immediate productivity of the graduate. In a word, they wanted the college to be an apprentice training school for their current business. The colleges for their part did not know enough to know that industry was not generally competent to write educational specifications, nor is it today. Possibly the scheme had some merit in the very early days of formal technical training when changes in industry were relatively few and gradual. It wasn't long, however, before both industry and the college were following an old trail, blindly oblivious to the fact that, except as to fundamentals, no college or technical school could hope to keep fully abreast of the rapidly changing and advancing needs of applied science industry. No matter how they tried to make established educational practice fit an outmoded concept, every one of their graduates who entered industry had to become some sort of a freshman in a new school.

In the main those students who fared best were those who had the best grounding in the basic sciences and in the rather simple principles which underlie what we term engineering.

That great engineers evolved from this dismal process, and there were many of them, was rather in spite than because of the well meaning efforts in their behalf. At a time when applied science in some sector or other was the great magnet which attracted imaginative young men, it was inevitable that it would pull into the current of formal training many who would have become great engineers in any event. The proof of this is that many of the greatest engineers of the past fifty years had

little or no formal training, because they had been deprived of opportunity for it.

Things have improved a great deal since the nadir of which I have spoken, and possibly I have painted the picture in darker colors than it deserves. Nevertheless there is, I think, still a long way to go. Tradition and vested departmental interests are hardy "beasties" which are difficult to modify or kill, particularly in democratic societies such as colleges and universities should be.

However, engineering in any field is at bottom a very simple thing. In any sector it is merely the practical application on a large scale of the facts of that part of fundamental science to which it belongs. As fundamental science expands and changes, so must its engineering adaptation. The ground rules of engineering and industrial research are essentially the same as those of fundamental science with a few simple additions.

The size of the things with which engineers deal may be a thousand times or more greater than those of the laboratory but they are not different in kind. It is a truism that "If you can do a thing in a laboratory you *may* be able to do it commercially, but if you can't, you can't."

The things with which engineers have to deal that do not generally bother the fundamental scientist are time; money in the sense that it is a measure of practicability; and a few techniques which long experience has shown to represent good engineering practice. No two industries mix these several factors together in the same proportions, but all employ them and properly undertaken knowledge of them is indoctrinate in the student.

Before turning from a scrutiny of the past to what might be a course for the future by way of improving engineering education, I should like to say a word or two about my own experience both as student and employer of scientific and technical men.

As I look back over my career, it seems clear that while I gleaned a vast amount of factual data from my formal education, my real education as a scientist and engineer was hardly connected with it and much that I learned from it I have forgotten or discarded as excess baggage.

The things that have really profited me I learned from intimate association with two men of widely different backgrounds—neither of whom ever tried to *teach* me anything. One of these was one of the world's great physicists, A. A. Michelson, and while I took some of his graduate lecture courses, what I really learned from him was acquired in the lowly capacity of serving as his research assistant. The other, many years later, was a great engineer, J. J. Carty, and again by being an assistant.

Both men were scientists by instinct. Michelson was a scholar by virtue of the best training that the world could give. Carty had nothing but a poor high school education on which to build, but in the end he had a greater understanding of the power of science and a greater respect for it than Michelson even.

Both men were meticulous in their search for basic truth in every problem they attacked and neither ever attached his name to trivial accomplishments. Both acquired by hard study a marvelous capacity for expressing themselves in simple concise language which their scientific and technical associates respected and which intelligent laymen could understand. Neither of

them recognized any compartmentalization in the domain of science or engineering or of any other domain of learning for that matter. All who were privileged to work intimately with them received a liberal education.

While we cannot hope to have our colleges and technical schools staffed wholly by Michelsons and Cartys or their like, and wouldn't want to if we could, I do think we can take a leaf from the book of their methods and incorporate it to advantage in the program of our future engineering educational program.

In what I am about to say in conclusion, I wish to make it clear that I have in mind the part of engineering education designed for those who give promise of rising to places of responsibility in their profession. I do not have in mind the education of the large number of men in the range between the trade school and colleges and technical schools of the first rank. I have little doubt that this large sector will be adequately taken care of.

Because engineering is merely applied physics, chemistry and mathematics, I would strengthen the courses in these subjects and would do everything possible to give the student a real understanding of the methods of scientific research and of the revolutionary things that can come out of it. To the extent that it can be done, I would carry on engineering training in intimate relationship with graduate research as is done at Cal. Tech. and M. I. T.

I would reduce the number of baccalaureate engineering degrees to the minimum, if not to a single one. The multiplicity of them simply tends to confuse the picture and to a large extent gives a false impression of what men are. Since any of the many science applications can be used as educational disciplines and since young men for one reason or another have particular bents, I would give wide latitude in choice of fields but not of courses in those fields. Only the experience of maturity can tell how best to group courses to attain a desired end.

I would emphasize English as a tool and would do everything possible to insure that the student recognized that when used by one who had mastered it, it is an extremely powerful and very necessary tool.

So far as the strictly engineering courses are concerned, I would first subject them to the acid test of scrutiny to see that they were directed toward the indoctrination of principles which apply to all engineering and then I would squeeze them down as much as possible in the matter of time. So too with the other courses which may be thought to be necessary parts of a man's kit bag when he gets his sheepskin. I would employ salvaged time in a way to stimulate independent thinking and study.

You may say that I have outlined the rough skeleton of courses in applied physics or chemistry rather than courses in engineering. Maybe I have, because it is difficult for me to know the difference.

What my experience and observation have taught me is that men soundly equipped in basic science; who know the power of its methods and the use of its tools; who are grounded in the proved techniques of good engineering and who can express themselves clearly and concisely make good engineers.

Further, they can tackle problems in any field of engineering no matter what their specialized training because they know how to go about solving engineering problems as a class. The kind

of knowledge and training which enables men to do this is best acquired in institutions of learning which are organized for the purpose—it is difficult to get otherwise. On the other hand, much of what has made up engineering education in the past can be better done outside such institutions—either in actual industry or merely by stimulating the student's curiosity to the extent that he will dig it out for himself in his own way. He will value and remember knowledge so acquired, whereas he will more likely than not discard it if he feels it is something forced on him.

Some of the things which have been done during the present war are striking examples of how powerful is a real command of basic science and its methods and how readily those who possess it can take over engineering problems of great magnitude and great complexity.

One of the most striking examples that has come to my attention during the war is that of producing in huge quantities a very dangerous substance. The skilled engineers in this general field said it was too dangerous to attempt on the scale required. So what happened? Top-flight physicists, chemists and engineers in one of our educational institutions who really knew their basic science first hand set themselves the job of doing what was said to be impossible. No one of them, so far as I know, had ever had any real industrial or engineering experience. They did know what constituted good engineering however.

When I saw the plant which resulted operating safely with its hundreds of employees, without having had a single fatal or even serious accident, it was to see a factory from which many an established plant could take lessons in efficiency and management. It was run by a fundamental science research man who expected to go back to his test tubes when the show was over. He did not claim to be an engineer.

In closing what is in effect a plea for a strengthening materially of the basic science content of our engineering courses to the end that men may be better equipped to cope with any kind of problem that confronts them, I cannot resist returning to the assault on compartmentalization and the multiplicity of degree designations it spawns.

Actually the designation of degrees which are awarded for work done in college or the wording of diplomas mean little in after life except as evidence that one has spent a certain time at some institution. The name of the institution usually conveys much more information as to the probable capacity of the individual than anything his sheepskin may say. It certainly weighs heavily in the balance of a prospective employer who wants a good man and is little concerned as to whether he was trained as a mechanical, electrical, chemical or fisheries engineer or as a physicist or chemist.

Whatever its value in helping to get its holder a job, it is certain that once he has it his sheepskin is of no help whatever in enabling him to hold it. What counts then is the native ability of the man and the character of the training which he has had.

Some of the best engineers I have ever known never took a single formal course in engineering, but they did know science and how to use it. So while I would not for a moment advocate abolition of courses in engineering, I am all for making them more strongly courses in applied physics and chemistry than they have been.

Education of an Engineer*

By A. R. STEVENSON, JR., and K. B. McEACHRON, JR.

General Electric Company

Neither of us has ever taught in an undergraduate college and we, therefore, hesitate to be very specific in our recommendations. On the other hand, we have had considerable contact with the hundreds of young college graduates who have been hired annually by the company with which we are associated and, therefore, we do have some ideas about the type of graduate the colleges are turning out and wish to suggest some improvements for your consideration.

During the war effort, industry has expanded rapidly and taken on many new, complicated and difficult tasks. As a result young engineers recently graduated from college have been given tremendous responsibilities which in the past would have been assigned only to much older men. They have carried these responsibilities superbly. This is a splendid tribute both to the young men and to the engineering colleges from which they were graduated. When an educational system has been turning out graduates who have met these present emergencies so splendidly, we hesitate to suggest changes.

It is particularly important to maintain some continuity in education in the transition period ahead. Not only in education but in all fields there is a tendency for people to feel that a discontinuity, like this war, furnishes an excellent opportunity to restart, after the war is over, on a radically different basis. Opportunists grasping for Utopias may lose much that was valuable in the old and greatly delay a return to stable operation.

We are all aware that there is a shortage of engineers now and the best informed people believe there will be a shortage of engineers after the war. It is, therefore, of first importance to get the colleges operating successfully on the old basis as soon as possible and then make improvements after the emergency of getting restarted is over.

During the war, college curricula for many students have been greatly altered. A splendid job has been done on an emergency basis in training men quickly. Many of the techniques may be of permanent advantage. On the other hand educational methods which were essential in speedy preparation for war may not be advantageous in the long run.

It is felt by many that time is required to absorb an education properly. For the best effect a certain amount of leisure and experience must be interlarded with more formal education. The colleges should return to a four-year course interspersed with vacation periods.

It would be a great advantage, however, if these vacation periods could be scattered throughout the whole year instead of all occurring in the same three summer months. Then it would

*Presented at the 52nd Annual Meeting, S.P.E.E. (Mechanical), Cincinnati, Ohio, June 22–25, 1944.

be easier for industry to give vacation jobs to both students and professors. We feel that the professors will do a better job of teaching if they can have practical experience in industry and that the students will learn more in their classes if they can have the proper kind of practical work during vacations.

In the prewar period, the college budgets provided for operating the colleges three-quarters of the year. Budgets will probably have to be increased if colleges are operated the year around. Either each professor would have to work and be paid for three months additional, or, still better, additional professors would have to be hired so that classes could be operated the year around while still maintaining three months' vacations for the professors.

There should be economy, however, in operating the facilities for the whole year rather than letting them stand idle for three months. Theoretically the same facilities operated the year around could handle one-third more students than on a nine months' basis. This would bring in additional tuition which would go part way toward defraying the increase in salaries.

In colleges where the tuition paid by each student does not cover the expenses incurred in educating him, the net budget of the college will have to be increased. The capacity of the college, however, will have been increased one-third and, due to the better utilization of the overhead, the additional net expense to be raised by a Board of Trustees or appropriated by a State Legislature would undoubtedly be less than this figure. In other words, by better utilization of facilities, the cost per student will have been reduced.

The shortage of engineers in the early postwar period may be made up partially by the return of engineers from the armed forces. About 1,000 engineers have left the General Electric Company to join the armed forces. By the time the war is over, this figure will have increased to perhaps 1,500.

We expect to be urgently in need of these engineers returning from service to help in the colossal engineering undertaking of "beating swords into plow shares." If they can be supplemented by a continuous flow of undergraduate engineers working for us in a continuous succession of three months' vacation periods, it will be very helpful.

Meanwhile, there will be many men who have been A-12 or V-12 students in the various Army Specialized Training Programs or the Navy College Training Programs. Some of these programs have been of only four or six equivalent semesters in length and, while of scientific and elementary engineering material, do not attempt to cover the usual ground of a degree program. Others are eight semesters in length and do lead to a Bachelor of Science degree in many of the colleges, although the engineering content has necessarily been slanted toward preparation for training as an officer.

Particularly since the Congress has passed the "G. I. Bill," we hope that all of these Army and Navy students will return to the colleges to complete or to re-orient their engineering education. Industry will be in need of these potential young engineers to take the place of the usual output of the colleges which has been practically nonexistent during the past few years.

Wherever accelerated courses have produced narrow specialists or where it has been necessary to pump information into the students without sufficient

time to absorb the fundamental principles, we hope that the colleges will put more emphasis than ever upon the student's obtaining a real understanding of the fundamental principles of engineering during any re-training period. Most of the detailed handbook data originate in industry where they are used and the colleges should concentrate on the fundamentals, leaving to industry the use of "handbooks."

America has long been noted for its educational system, in particular for the high level of the average intelligence of its citizens. In our desire to improve the average intelligence, we have neglected the brilliant individuals. Gerard Swope * in his "Response to the Award of the Hoover Medal" expresses this point very clearly.

> The English, in their universities, through their emphasis on the "honours" courses, have been successful in the development of the exceptional student. I remember very well a talk I had many years ago with Lord Rutherford, then Sir Ernest, the head of the Cavendish Laboratories of Cambridge University, and himself an outstanding scientist and a winner of the Nobel Prize. We were discussing engineering education in England and the United States. He said, "I grant that the average of your engineering graduates is higher than ours, but you can't touch our honour men. We don't pay much attention to the average man—he may get something from the atmosphere—but we devote ourselves to the top quarter of the class." I came back filled with the idea that if we could keep the average of our engineering graduates as high as it had been and still give more time and opportunity to the exceptional student, we would make a real contribution to engineering education and eventually to society, by engineering leadership.

It is being realized more and more that learning apart from doing is not very effective. The teachers should think up practical problems to illustrate what is being taught. This does not mean that education should consist of practical problems solved by the use of handbooks. The theory should be thoroughly understood but it should simultaneously be illustrated with practical problems which should be simple enough so that the student can solve them by his own ingenuity.

The trouble with practical design problems which have been given in engineering courses in the past has sometimes been that they were too difficult or outside the range of experience of the student, with the result that the professor really had to show the student how to solve the problem.

In such a course the student, instead of being stimulated to develop his own initiative, simply copies what the professor dictates. This is very deadening. It is perhaps one reason why so many of the very fine young engineers who come to us from colleges tell us that the one thing they do not want to do is to design. They have obtained an erroneous idea of design from humdrum courses where they simply did the routine work of carrying out the professor's instructions. These same men, when given the opportunity to really use their own creative ability in designing something, no matter how simple, begin to catch the thrill of artistic creation.

Responsibility creates enthusiasm in education as in any other field of endeavor. Dr. Stevenson gave a talk on education recently in Wisconsin and

* Former President, General Electric Company; "The Engineer and Social Development," pub. *Electrical Engineering*, April, 1943, pages 157–158.

the discussion led into some of the broader fields in which an engineer should be interested. An executive from a nearby industrial concern said that he had made a great effort to get some of his young engineers interested in these broader fields, without much success. In reply Dr. Stevenson hazarded the guess that he had not made them responsible for some operation in which this broader knowledge was required.

The fact that a young man has taken up engineering is an indication that he is of a utilitarian turn of mind. It is very hard for him to get interested in learning anything just for the sake of learning. He can put immensely more enthusiasm into the learning process if he can see an immediate use for the knowledge. Let us hasten to add, however, that an education would be very limited if it only included items the immediate use for which was obvious.

The attitude of the undergraduates would be greatly improved if they were made responsible for using the information which they are learning in work outside of the classroom. Many undergraduates earn their way through college; in fact, past results seem to show that those men who do earn their way through college benefit greatly from the experience. However, outside work of this character could be made even more valuable if the knowledge taught in the classroom could be directly applied to outside work. The coöperative plan under which some schools operate is a step in this direction.

One of the most brilliant men who ever went through Princeton University earned his way by tutoring. He didn't teach just one subject, he taught everything. Every course he took he had in his mind that he would make money teaching that course to someone else. This habit of thoroughly understanding and then immediately making use of every opportunity for education which came his way, has produced a very versatile and successful all-round business man.

In the Advanced Engineering Program in the General Electric Company we select from the best young engineers in the Program the one to supervise the same class the next year. It is not a case of the "blind leading the blind" because these young supervisors call on several dozen of our older engineers to help them, but these young engineers are completely responsible for the classes which they supervise. They will all testify that while supervising the class they learn twice as much about the subject as they did when taking the class the year before.

This is somewhat similar to the Preceptorial System which Woodrow Wilson set up at Princeton where courses were run by a small number of older distinguished professors and a large number of very youthful graduate students who were called Preceptors. The difference, however, is that in the General Electric Company, we make these young supervisors responsible for the courses and the older engineers act as consultants and visiting lecturers. We also have the opportunity to select the best of the men going through the class, whereas the Princeton system was limited in the selection of Preceptors to young men who wanted to stay around the college a year or two longer. In some cases the men were not, by any means, the best men in the preceding class.

Mr. D. C. Prince, Past President of the A.I.E.E. and Vice President of the General Electric Company, noting the

successful operation of the Advanced Engineering Program, has suggested to some of his friends in the colleges that they use the best undergraduates to help with the teaching. Under such a system the best men in any class would be given an opportunity to teach the succeeding class. Sophomores would teach freshmen, juniors would teach sophomores, and seniors would teach juniors, etc. The success of the scheme would depend upon whether the faculty was willing to give these young instructors real freedom and make them feel responsible for making the most of a creative opportunity. I have talked to one or two deans about this but they could see many obstacles with which most of you are familiar.

If it could be accomplished, however, it would give an opportunity to carry out the suggestion which was quoted earlier from Mr. Swope. The average pupils would simply go through the classes, the outstanding pupil would get the extra opportunity, responsibility and incentive of teaching the classes.

These carefully selected young instructors, if given proper freedom, could do a much better job of leading than some of the other instructors who remain on the college payrolls without promotion year after year. The substitution of these undergraduate leaders for regular instructors would release sufficient funds to hire a few really brilliant, outstanding professors, world famous experts in their fields. In addition to professional competence, it is even more important that these men have the ability to work closely with the undergraduate leaders, stimulating and inspiring them, yet making each completely responsible for his class.

During the depression a large number of colleges were given the opportunity of adding to their physical plant by grants from the federal government. Nothing comparable, however, has been done to improve the salaries of college staffs. In fact, the new buildings result in increased maintenance and depreciation expense which in turn reduces the money available for professors' salaries. Certainly the men are more important than buildings and adequate salaries for the teaching staff should thus be the first concern. With adequate salaries, it will be possible to attract to the profession men who would be outstanding teachers and who would lead and guide the college students rather than give them practice in handbook engineering.

Many schools will undoubtedly never be able to employ a full complement of outstanding teachers. The use of undergraduate leaders would make it possible for these colleges to obtain maximum benefit from a relatively few "born teachers." There is no substitute for the inspiration and guidance which such men can contribute. As Harvey N. Davis in his article, "Unconscious Tuition," * so clearly emphasizes:

> A great teacher is a man whose personality is so attractive, and whose character is so fine, that by unconscious tuition he wins the admiration and lifelong devotion of his students and all unconsciously influences their ideals and molds their characters, so that they are forever after better men for having sat under him. What one learns from such a great teacher is often a by-product of minor importance, rather than the main object or chief advantage of taking his instruction. Would that every American college faculty might be composed wholly of such men!

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* President, Stevens Institute of Technology; pub. *Mechanical Engineering*, February 1939.

We feel that there is nothing more important than teaching. We ought to have the best and most capable men in our nation guiding the education of our youth. Nothing would have a more beneficial effect on the future of our country. This type of teacher is more important than buildings, but he should be supplemented and freed from the routines of teaching by younger instructors. The routines of teaching, which might be deadening to men who have to carry on the same routine year after year, would not appear as routine but as creative opportunities to brilliant young men who were selected to do it for only one year at a time as part of their own education.

We have found in the General Electric Company that by running an educational system in this way we never collect any deadwood in the faculty. Imagine the high quality faculty which could be built up in a college where all the lower teaching positions were filled by the most brilliant undergraduates and where only the leading men were permanent.

In a Baccalaureate Address at the Massachusetts Institute of Technology, Mr. H. W. Prentis, Jr.,* made the following statement:

> Here, alas, is where too great a degree of specialization often defeats its own ends. Lack of intellectual breadth inhibits the flowering of mental resourcefulness. Thus electrical engineers sometimes disappoint us by proving to be little more than skilled electricians; mechanical engineers, versatile mechanics; civil engineers, mere surveyors; lawyers, conveyancers; and, in this august presence, dare I add that professors may even become pedantic pedagogues.

* President of the Armstrong Cork Co. "Technically Trained Men in a Republic," June 4, 1940.

It is obvious that the electrical engineer has to know mechanical engineering and we think careful examination will indicate that the mechanical engineer has to know a great deal about electrical engineering because so much mechanical equipment has electrical motors and controls and so many mechanical measurements are done with electrical devices.

In 1936 Dr. Stevenson wrote a paper entitled "Success in Engineering"† giving a list of fifteen broad fields with which all-round air conditioning engineers should be familiar, which concluded as follows:

> The above partial list will indicate that there is almost no limit to the ramifications of even one branch of engineering such as air conditioning.
>
> Thus we can see that without native ingenuity, common sense and experience, technical training cannot make an accomplished engineer.
>
> He must have a broad knowledge of other subjects that he may fully understand the ramifications of each problem that confronts him.
>
> He must understand cost and manufacturing processes so that his ideas may be placed at the service of the public at a price which the public can pay.
>
> Above all, he must be a salesman for his own ability and ideas.

Breadth of education is a necessary basis for good judgment. Henri Le Chatelier, the famous French metallurgist, said,*

> Activities physical and intellectual are powerful tools, but, like every tool, it is necessary to employ them judiciously, to

† Reprinted May 1936 *Refrigerating Engineering*, Volume 31, No. 5.

* "The Creation of an Intellectual Elite in Science and Industry." Contained in a pamphlet entitled "Creative Engineering," published by the American Society of Mechanical Engineers, July 1944.

let oneself be guided by *good sense* in the selection of the problems to be studied. . . .

A second form of judgment is the *critical sense,* which is as indispensable to the scientist as to the industrialist in discerning the causes of errors in his measurements or to forewarn him against erroneous interpretations of observed facts. Too often this quality is lacking in inventors who persist in their ideas, in spite of evident disappointments.

It is often remarked that there are three steps in a successful engineering enterprise—

a. Selecting a worthwhile problem.
b. Solving it.
c. Selling the solution.

It seems obvious that a breadth of education and knowledge is required to select worthwhile problems and it should be equally evident that a broad cultural background is also necessary to selling the solution. Industry has encouraged the colleges too much to focus their attention on the middle and narrow phase, solving the problem.

Many engineers lack the ability to handle the third step, selling the solution. As undergraduates they probably felt that English was an unnecessary subject not worthy of their attention. The same was probably true of public speaking.

This attitude could undoubtedly be avoided if these subjects were properly integrated with the rest of the curriculum. Much more interest could be aroused in the subject of English if the English professor could convince the student that his course in English was helping the student to write the solutions for problems in his other courses in more understandable form and if the professors in these other courses could coöperate with the English professor by insisting on good English presentations. In order to obtain this sort of coöperation probably the English professors should further educate themselves by taking some of the engineering courses and the engineering professors should reciprocate by taking some of the English courses. We know this is not done at larger colleges but it was the practice at one small college with which we are acquainted and we know it has been beneficial.

In this connection, we have considerable sympathy for a recent article * in the JOURNAL OF ENGINEERING EDUCATION with regard to English teachers:

> They learn from their students. An interest in technical subjects has been born, and the old literary bias against them is disappearing. A notion of culture as an attitude assumed towards any subject, technical or philosophical, rather than as familiarity with certain arts and books begins to appear, and the teacher of Wordsworth or Thoreau finds himself engaged, and happily, in discussing baking methods or the development of alloys. For the teacher of speech, too, there can be a realization that the orderly description of a coke-oven is just as valuable practice as an argument on Fascism.

There is a golden mean in everything useful and after the English teacher has won the enthusiastic support of his engineering students by indicating his own knowledge and enthusiasm for their subject, he can lead them to a wider acquaintance with English literature which is necessary in order to make their writing attractive and eloquent.

Very recently in the General Electric Company eight of us were preparing

* "English in Basic Army Courses" by Alexander M. Buchan, published April 1944.

short papers for an important sales presentation. We got invaluable help from one of our older engineers who, in addition to being a good engineer, has been a lifelong student of poetry. He could suggest just the right words to give the proper shades of meaning.

More recently yet, at a large meeting, the chairman opened the discussion with a poem which had been prepared for the occasion by one of the leaders of the group. When he finished, one of those present remarked, "These poets can say so much with so few words. How else could the subject of this meeting have been more clearly and concisely summarized?"

College education should provide opportunities for engineers to develop leadership. As a member of the Civilian Advisory Council of the Military Training Division of the Ordnance Department, Dr. Stevenson's attention was called to the fact that in the early days of the war 15 per cent of the men in the Officers' Candidates' Schools were being washed out. Only a fraction of 1 per cent were washed out for lack of technical and classroom knowledge. Nearly the whole 15 per cent failed for lack of leadership. In these schools, very strenuous efforts have been made to develop leadership. This is done by athletics, public speaking and assignments of responsibility on the drill ground and in the squad room. There is very little in the present formal college curriculum which develops leadership or an understanding of human relations.

If we could adopt the practice of giving responsibility to the young men helping in the laboratories and in the classroom, a step would have been made in the right direction. It is probably because of a lack of responsibility in the laboratory and classroom that representatives of industry, when recruiting college graduates, place so much stress on their extracurricular activities.

If these extracurricular activities could be tied in with a course in human relations where the human problems, which the young man encounters in managing his fraternity or team, could be discussed with an older man who is an expert in such fields, the young man would probably learn more quickly than by the present trial and error method.

There is a need for an enlightened understanding of human relations by engineering students because engineering education has in the past largely dealt with "things" and "things" respond to hard, cold logic while people respond only to persuasion.

This is well illustrated in a talk * by Dr. J. Duncan Spaeth, the famous professor of English and coach of the Crew of Princeton, in which he points out that an engineer, having built a bridge, would not pat the bridge and say, "Dear Bridge, for my sake stand firm when the floods come." Bridges do not respond to that sort of persuasion. Conversely people do not always respond to logical reasoning.

There has been a great deal of conversation lately about the fact that engineers should take an interest in public affairs and it has been suggested that more cultural courses should be included in engineering curricula to provide engineers with the historical background necessary to vote intelligently. It is important, however, that history be interpreted properly.

When we were children we read

*"Law for Man and Law for Thing"—News-Letter of the Princeton Engineering Association. Given at Philadelphia in 1923 for the Eastern States Gas Conference.

various history books. They all painted Napoleon as heroic and noble. Many of us have since come to believe that Napoleon may have done many constructive things but that the sum-total of his influence was pernicious. Probably the people in England at the time of Napoleon felt very much about him as we do about Hitler today and yet not very long after Napoleon's death books written in England were lauding him as a hero and weeping sentimental tears about his confinement on the Island of St. Helena. Fifty years from now, are we going to have a flood of biographies in the English language, praising Hitler's good points and forgetting all about his pernicious influence?

We have lived through the prohibition era. A great many well-meaning people thought that prohibition would be a good thing. It turned out that it could not be enforced and that its influence was, therefore, pernicious.

Just as temperance could have been more effectively encouraged by advertising the evils of drink than by attempting to enforce prohibition, so ultimate improvement in the conditions of the poor may be more nearly accomplished by encouraging free enterprise than by attempting to force an equal distribution of wealth and security by government fiat which would probably "kill the goose that lays the golden egg."

The question we are raising is whether there is any sense in including cultural courses in history in engineering curricula if the students are going to be taught to misinterpret history. If the history courses are going to help make more intelligent voters out of the students then the students must be taught to interpret history correctly.

There is nothing new under the sun. Most of the political experiments have been tried in the past. It seems rather rash for anyone to rush in and try to exert influence on the affairs of our day without knowing what has been tried and what has failed or been successful in the past. Even our academic brethren are not too well educated in this respect. The facts of history may have been given correctly but have the history teachers felt sufficient responsibility for interpreting the facts correctly? It has been said that a little knowledge is a dangerous thing and history misinterpreted is perhaps more dangerous than no history at all.

In relation to religion, it is said in the Bible * "By their fruits ye shall know them." The prewar educational system has produced such a large number of fine engineers that it must have been a good system. We, therefore, hesitate to suggest radical changes, particularly in the postwar period when the most important problem is to get the educational system back to a good fundamental basis quickly.

There is probably no harm, however, in bringing up certain suggestions for consideration. Although we all believe in democracy and would like to see the level of the average man raised, it seems fairly obvious to many of us that democracy in the best sense must provide opportunities for capable men to rise above the average. Such men make the real contributions which benefit the masses.

Prewar engineering education has been criticized for paying too much attention to the average and backward and for failing to inspire and challenge the more brilliant students. Special consideration should be given to their education in the postwar period.

* Matthew 7:20.

Since all of us recognize that anyone learns twice as much when teaching a class as when taking it, one of the best ways to give the brilliant students additional opportunity is to make them responsible for teaching. This practice would relieve professional teachers of much of their routine work which would serve as creative opportunities for brilliant young students. Such a student leader would teach any one class for so short a period that he would never lose the thrill of the adventure.

Engineers should be broadly educated not only in all branches of engineering but also in cultural fields. The teaching of these latter subjects, especially history and economics, must be very carefully done to emphasize properly the facts of these subjects in relation to the democratic way of living.

It has often been remarked that you can use the Bible to prove anything and the same might be said of history and economics. If such subjects are to be included in engineering curricula, a special effort should be made to assign professors who cannot only teach the facts but who in addition are broad enough men to guide the students to interpret the facts correctly. We do not want history and economics teachers who will be like the questionable scientists whom Henri Le Chatelier* describes:

> They are not able to make up their minds to abandon their hypotheses when they are contradicted by facts; they try to explain the disagreement by new hypotheses and stick to their first error.

It is a very noble undertaking to work toward the creation of leaders. The prosperity and the future of our country and of the world will depend on this.

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* "The Creation of an Intellectual Elite in Science and Industry." Contained in a pamphlet entitled "Creative Engineering," published by the American Society of Mechanical Engineers, July 1944.

Of Interest to Members

ENGINEERING NEWS RECORD, November 23, 1944, page 10:

"According to a survey made in the larger cities of Illinois and Indiana, three out of every four high school seniors expect to go to college.

"The effect of this highly mechanized war and the age of specialized training is revealed in the fact that 43.3 per cent. of those planning to attend college will study engineering, the other choices in order being medicine, law, business administration, agriculture and physical education."

A Direct Velocity Construction of Kinematic Chains

By GEORGE F. BUSH

Assistant Professor of Graphics, Princeton University

A useful graphical method for the determination of the velocities of kinematic chains, such as that schematically represented in Fig. 3, has been described by Roseanauer,*† but it does not seem to be widely known in this country. The author therefore offers the following elements from his translation of the original.

The procedure is based on an extension of the well-known theorem: The projections of the velocities of the various points of a straight line on the direction of the straight line are equal (Fig. 1). (The usual assumptions, such that all points of the chain move in a plane, or parallel planes, and that the links are rigid bodies, are made.) The extension consists of making the straight line go through a joint which connects the two moving planes. The considered points, of which the velocity projections on the straight line are equal, may belong to the two planes. The proof of this extension can be directly inferred from Fig. 1. The triangle ADE of Fig. 1 will, when turned 90°, be in the position $A'E'D'$ of Fig. 2, and, since the equal components of Fig. 1 will then have their extremities on lines L and M, it follows that the termini of the turned velocity vectors will lie on a straight line M parallel to the line L, as in Fig. 2. (All turned vectors are those which have been turned 90° in either the clockwise or counterclockwise direction from the actual vectors.)

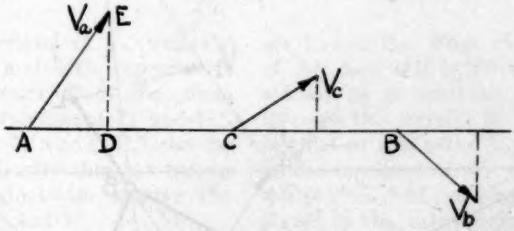

FIG. 1

As a first example, take the open kinematic chain of Fig. 3. The chain consists of four links, of which three, AK, BL, and CM, are fastened through turning pairs to the fourth ABC

*Riga University, Mechanical Faculty, Series 1, No. 14, 1936, p. 373.

†"A Direct Velocity Construction of the Heysinger Steering Mechanism" by N. Rosenauer, Riga University, Mechanical Faculty, Series 1, No. 15, 1936, p. 384.

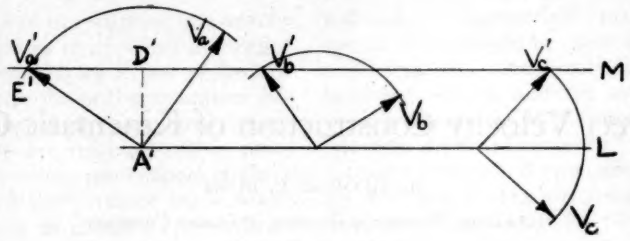

FIG. 2

Let the counterclockwise-turned velocity vectors V_k', V_l', and V_m', of the points K, L, and M, be given in relation to the fixed plane. To be constructed are V_a, V_b, and V_c relative to the fixed plane. Find the intersections D and E of the straight line KA with LB and KA with MC. (Points D and E have been called "auxiliary points" by some authors of this country.) Consider D and E as points of the plane ABC. According to the extended theorem, the terminus of V_d' will lie on two straight lines, one of which is drawn through the terminus of V_k' parallel to KA, and the other is drawn through the terminus of V_l' parallel to LB. Similarly, the terminus of V_e' is the intersection of the two lines which are drawn

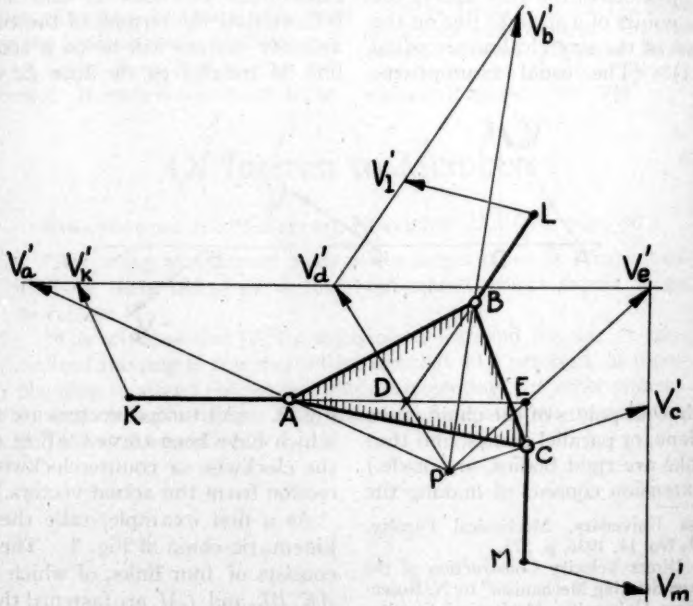

FIG. 3

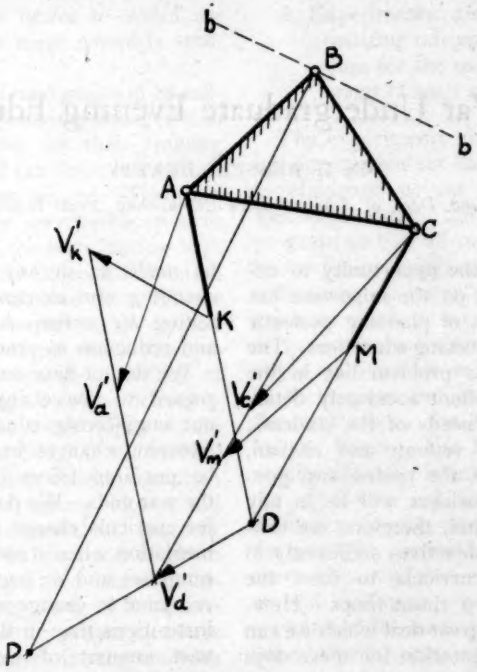

FIG. 4

through the termini of V_k' and V_m' parallel to KA and MC, respectively. The instant center P of the plane ABC is the intersection of V_d' and V_e'. From it, V_a', V_b', and V_c' can be determined. Finally, these are turned back clockwiseclockwise to give the required V_a, V_b, and V_c.

As a second example, involving perhaps a sliding pair, take the open chain of Fig. 4, which consists of three links, ABC, KA, and CM, the latter two of which are connected to the first through turning pairs. Suppose V_k' and V_m' are given, together with the direction b-b of the velocity of point B. The latter may be determined by a sliding pair. To be found are V_a and V_c. First, the intersection of AK and CM is D, which is considered as a point in ABC. Lines through the termini of V_k' and V_m', parallel to AK and CM, will intersect at the terminus of V_d'. The instant center P of ABC, relative to the fixed plane, is the intersection of V_d' extended and a perpendicular to b-b at B. Line PA determines the direction of V_a'; the terminus of which is on the originally-drawn line through the termini of V_k' and V_d'. V_c' is likewise determined. V_a' and V_c' are now turned back to give the required velocities V_a and V_c. V_b' can also be determined in this manner, or in a slightly different manner.†

Post-War Undergraduate Evening Education*

By H. RUSSELL BEATTY

Head, Dept. of Administrative Engineering, Pratt Institute

I appreciate the opportunity to express my views on the important but difficult problem of planning post-war undergraduate evening education. The difficulty in this problem lies in the fact that we cannot accurately determine what the needs of the students, both returning veteran and civilian, and of industry, the professions, government and business will be in any exact manner and, therefore, we cannot detail our objectives sufficiently to build special curricula to meet the special needs for those times. However, there is a great deal which we can do now in preparation for these days of greater opportunity.

After the war, people will earn their living very much as they did before the war. True, there will be some new industries and probably more government than before, but most people will earn their livelihood as farmers, factory workers, service employees, sales people, office workers and in the professions, very much as they did in the past. Relatively few changes will take place in our economic pattern for such changes must evolve slowly and our educational system will undergo change with them, either leading or lagging, depending upon its leadership. It will be very dangerous to change either too extensively, for such changes should be made as in any experiment—by changing one element at a time and noting its action—before acceptance and reduction to practice is advisable.

We do not have sufficient facts with regard to the changes necessary in our engineering education to attempt sweeping changes in our curricula to be put into effect immediately after the war ends. We do have many ideas for curricula change ready for experimentation when students return to our campuses and we are now much more receptive to change in our educational institutions than in the past due to the vast amount of experimenting and change required to meet the needs developed by our war effort. We must be ready to take advantage of this fact when the war ends.

It is quite obvious that, after the war, there will be proportionately less professional engineers than before the war and proportionately more individuals with sub-professional technical backgrounds due to the effects of the war on our technical education programs. This is likely to result in a considerable increase in enrollment in our professional courses but would appear to cause somewhat reduced enrollment in the sub-professional field. However, I believe we will experience a large demand in the latter field because of two reasons—first, we have never trained enough men at this level—and second, many veterans, particularly the more

* Presented at the 52nd annual meeting, S.P.E.E. (Evening Engineering Education), Cincinnati, Ohio, June 22–25, 1944.

mature, will not desire to spend the time to secure a more complete technical training.

The number of men who will be calling on the engineering colleges and technical institutes for their training after the war will tax these institutions to the limit, if not beyond. There are two groups to be served—the returning veterans and the boys leaving high school. The U. S. Office of Education in their survey showed that 17 per cent of veterans expect to go to part time school or college when they return, and approximately one-third of these desire college courses, or nearly 6 per cent of the total. This would give in numbers 500,000 to 600,000 students for evening college education from the veterans group alone. Of this number approximately 11 per cent or 60,000 might be expected to go to engineering colleges and technical institutes. However, many of these men cannot be served at present because they will be located in communities where this education is not available. It would appear to me that one of the challenges that we face in evening education is how to make the opportunity for such education available to those located in other than large urban areas.

I believe that the following experiments aimed at improving our evening education for professional engineers should be made:

1. Experiments aimed at broadening our curriculum.
2. Experiments aimed at introducing more of the "humanistic social stem" into our curriculum.
3. Experiments aimed at securing a greater degree of coöperation between industry, the student and the educational institution.
4. Experiments aimed at individualizing our engineering education for the maximum development of each student.

The experiments aimed at broadening our curriculum should be designed to eliminate, as far as possible, all specialties from our undergraduate program so that all our graduates will be as junior engineers and that specialization will occur on the job or in graduate work rather than in the undergraduate curriculum. Some options might be available in the latter years of the course, but the more general the curriculum, the better education for the future. For how can anyone predict what the future holds in any of the specialties? I have heard much discussion among engineers regarding the probable demand for civil engineers after the war, many claim that we will need large numbers, while others claim the demand will be small. Some schools are considering the elimination of this curriculum. It is next to impossible to predict the demand for electronic engineers, aeronautical engineers, administrative engineers, safety engineers, mechanical engineers, electrical engineers, chemical engineers, etc., six to ten years after the war ends, or four years after the war ends for that matter. Most states have one license for engineers—why not one degree? If the student receives a solid training in engineering fundamentals with general knowledge of the art of applying these sciences to the solution of various problems encountered in the various branches of engineering, he is far better fitted to adjust himself to the varying demands for his services than if his primary training is too specialized. Many students choose the wrong fields of specialization because

they do not have enough knowledge of the field and their aptitudes for the work in the field when they are required to make their choices. Once the choice has been made, they cannot change without a loss of time—this results in many students remaining in one field while they prefer another. Many sacrifices are made in the overall education of the engineer and in complete grasps of all engineering fundamentals in order to bring him well along in a field of specialty. This often results in an electrical engineer being very weak in the fundamentals of fluid mechanics and a civil engineer being very weak in the fundamentals of electronic tubes, etc. I realize that what I propose involves a tremendous amount of work in the development of new courses, the writing of new texts, all designed to broaden the training of the engineer. To attempt to do this with present texts, courses and prejudice will cause failure. The changes should begin in the first college courses in mathematics, physics and in chemistry and continue throughout the entire curriculum.

This brings me to the second point I wish to make, which ties in very closely with my first one. We should introduce more of the humanistic-social stem into our curriculum and experiments with this in mind should be performed. The Committee on Engineering Education After the War of this Society has discussed this at length. I desire only to mention that broadening the curriculum to include these courses is only possible at the expense of specialization and to advocate the following courses among those receiving consideration: English: composition, literature and speech; Economics: Principles and Problems; the History of Civilization; Political Science; Geography: Physical, Economic, and Political; Art Appreciation for Engineers; Industrial Psychology, Industrial Organization and Management, Industrial Marketing and Financial Management. If all of the above were used, it would amount to about thirty-six credit hours or about 25 per cent of the entire curriculum, which, I believe, is not unreasonable.

The third series of experiments which I suggest are concerned with cooperation in evening education between industry, student and educational institution. To my mind, our evening engineering schools have neglected a tremendous opportunity to improve their service by failing to develop this coöperation. The evening division, with its employed adult student, has far better opportunity for such coöperation than the day division. The student is already employed. All that is necessary is to devote a sufficient time to work coöperatively with industry in the development of the man to his maximum potentiality. It is my observation that very often those in industry do not utilize a man to his maximum abilities because they do not know the extent of his upgrading from period to period. If the training director in the plant and the faculty member appointed as advisor to the student could meet at least once a year—more often if it could be arranged—and the student's development, program of courses and the like reviewed, it might often be possible to place the man on work in industry which would coördinate with his school development to the benefit of all concerned.

My fourth and last plea regarding evening engineering education is that we do more to individualize our engineering education. Our present

method of classroom instruction fails to work the top quarter of the class while the lower quarter is greatly overworked. This results in retarding the brilliant student so that in many cases he becomes mentally lazy instead of the superior product which we might have made him. This is not his fault but ours! I realize that the more individual we make the instruction, the more expensive it becomes, but I believe there is much we can do within our means. At Pratt Institute we arranged elective options for students who were above the average in their grades. These options were not additional courses that they might elect (although I believe this is done in some colleges) but were fields of work in which these students wished to develop themselves more intensively than the regular courses permitted. The students were assigned to the faculty member best qualified in the option elected and the faculty member was available for consultation and to assist the students when they needed help. We found this program to be helpful to the students.

One of my professors in my undergraduate days was conscious of the same problem and solved it to his satisfaction by assigning to his A and B students, on occasion, special problems much more difficult than those assigned to the rest of the class. He carried this to the point of giving two final examinations—one for his A and B students which was considerably more difficult than the one for the balance of the class.

What method will prove best in your subject or college, I am not in a position to say, but I believe experimentation is needed to improve our instruction for the better student. Perhaps smaller classes, segregation according to ability or some other solution will prove best.

In addition to the professional courses offered by engineering evening schools, there is even a larger opportunity for such schools to give adult education through short courses of a sub-professional nature and through unit courses. Undoubtedly many veterans located near schools where such education is available will enroll in these courses. Because of the short duration of these courses, they should be intensive, highly specialized and designed to meet the needs of the industries in the local community. Only by maintaining close contact with local industry and by developing courses as the need arises will this work be effective. Our experience with E.S.M.W.T. will be most helpful to us in this work.

I feel that experiments to determine the proper changes to make in our evening undergraduate educational program after the war should be developed now and that they should include:

1. Attempts to decrease the specialization in engineering education at the undergraduate level.
2. Attempts to introduce more of the "humanistic-social stem" into our curriculum.
3. Attempts to secure a greater degree of coöperation between industry, the student and the educational institution for the benefit of all concerned.
4. Attempts to individualize the instruction so that the maximum development of each student is assured.

Visual Aids in Technical Writing at the University of Texas

By JOSEPH JONES

Assistant Professor of English

Instruction in the technical branches has long enjoyed well-developed visual aids of many kinds, and the war programs have greatly accelerated their use. Mathematics, the sciences, and the various fields of engineering make constant use of sound films, lantern slides, film strips, models, displays, and perhaps other types of visual aids to reinforce classroom teaching, with notably good effect. However, some of the other branches on the college level, English among them, have as yet hardly even reached the frontier of visual teaching. The result is that any experimentation in these subjects has to be of a home-made sort, with not much precedent to go by and not much help from commercial agencies whose business it is to promote the use of visual teaching equipment. Occasionally this may be a good thing, with necessity leading to novel creations, but generally speaking it is not so. Often the experimenter may feel that too much time must be taken up with the minutiæ of devising techniques and materials which others find already at hand, in which event he either reconciles himself to slow and painful progress or does not attempt it at all. Some things, however, may be done without too much expenditure. This article will describe a few of them and suggest others.

At the University of Texas, English 317—"Technical Writing for Engineers and Science Majors"—is a relatively new but rather large course, by virtue of the fact that it is required of engineering students and recommended for many science majors. There are several sections of it, all taught by men who are regular members of the Department of English. All the instructors use visual aids to some extent; and the composite picture of what is done is rather interesting.

I. Visual Aids in the Classroom

In the classroom, several different types of visual aids are in use. First, a semi-permanent display mounted on a "Multiplex" display stand is kept in one of the classrooms used most frequently for the course. In this display are usually to be found some specimens of student reports, examples of technical research papers, diagrams and charts of various sorts, and pictures of interest to students in the different branches. The instructor may occasionally make use of the display in his lectures and in class discussion, and the students are encouraged to examine it.

Second, a combination opaque (flat materials, books, etc.) and lantern-slide "Delineascope" projector is available in the same room. It is frequently used

by the instructor for the discussion of student reports, since it has the advantage of being able to show an individual paper to the entire class. The discussion of outline procedure, for example, is made especially effective by the projector; and other matters such as footnotes, paragraph structure, and miscellaneous details relating to the correctness and appearance of the work come in for treatment before the class. Similarly, materials supplementary to the text can be made easily available to all: specimen reports or research articles from periodicals; report-writing manuals other than the one being currently used; graphs, charts, flow sheets and all such mechanical aids, both in and out of their context.

The student likewise learns to operate and use the projector in the presentation of his oral reports. Most instructors at Texas require at least one oral presentation during the term —frequently the explanation of a diagram. The opaque projector is nearly always used for putting the diagram before the class, though upon occasion lantern slides, blackboard drawings, or simple apparatus have been substituted.

Certain classroom uses of visual aids, then, are fairly well-developed, though there are yet some unexplored possibilities, as will be indicated later.

II. Visual Aids Outside the Classroom

Two methods of presenting material outside the classroom have been tried at Texas, each with some success. The first was a general exhibit illustrating the aims and materials of the course, housed in a large display room of the Architecture Department. This exhibit, held early in 1944, lasted for two weeks and was visited by numerous students and faculty members interested in the course. Included in wall and table displays were discussions of the aims and methods in English 317; student reports of all kinds; examples of mechanical aids; specimens of technical papers and brochures; a panel on visual instruction; and a section devoted to technical writing in the war. Manufacturers and research organizations have responded generously to requests for illustrative material.

On a smaller scale, the same type of exhibit has been placed on a "Multiplex" display provided by the College of Engineering for the use of English 317 and located in the Engineering Library. Whole formally planned sections are mounted and changed from time to time, and a few panels are kept open for miscellaneous items of current interest. A general view of the course is thus available at all times to prospective students, as well as materials of special interest to those already in the course. In the latter part of 1944, for example, a special large section on the term report was mounted on several of the panels in the display. This had for its purpose the general improvement of the term report, particularly with regard to the use of the specialized indexes and the periodicals in the library. A specimen subject was followed through single pages taken from discarded monthly copies of such cumulative indexes as the *Industrial Arts Index*, with special attention to multiple headings and cross-references. Other general advice on a wide variety of matters connected with the term report was offered through humorous drawings clipped from such current magazines as *The New Yorker*. Associated with each drawing was some specific point about the term report, typed in large primer letters on

a colored label directly beneath the drawing. Needless to say, this display drew considerable attention and perhaps reinforced some of the many *do's* and *don't's* about term reports that stand in perennial need of reinforcement by any means at hand. In addition, entire classes are occasionally taken into the library and shown the use of periodical indexes in laboratory fashion.

These methods, we feel, have so far proved well worth the effort and money expended on them.

III. Undeveloped Frontiers in Visual Aids for Technical Writing

Technical writing is a subject which lends itself naturally to the use of visual aids, as does nearly any expository composition course. Some progress has been made, as the earlier sections of this discussion show; but much more could and soon should be attempted. The Army and Navy programs have shown many people these new ways for the first time, and have greatly encouraged those who were already moving in the new directions.

First, the sound film is an unexplored medium of instruction in English composition. Several possibilities offer themselves: a full-period film on the mechanics and organization of the long report; a short film on the handling of bibliography and footnotes; another on effective outlines and abstracts; still another on varying levels of technical language. Such films, if carefully prepared and made generally available, would do a great deal to encourage the study of technical writing.

Second, the resources of the film strip need to be extended to English instruction. Little or nothing is now available in the field. Here again, the long report might well be made the subject of a full-period film strip, with shorter strips on such subjects as mechanical aids, report forms, outlines, abstracts, reference forms, the use of periodical indexes, and note-taking. In some ways, the film strip is superior to the sound film, though not so spectacular: its speed can be varied; it can be easily stopped or reversed; the instructor can answer questions as the film is shown. Each type, however, has its own special uses and advantages.

How can such desirable progress best be made? Some of the technical societies, the writer believes, might well consider the idea of organizing and underwriting a program for the production of films to promote the study of technical writing. More funds are needed than individual institutions care to spend on really thoroughgoing and professional-quality projects; and adequate production facilities are seldom close at hand. The commercial producers are hesitant to risk any extensive explorations into what seems to them to be still untried territory. Some central direction with adequate financial backing is necessary to a profitable program; but, with this assured, as it might easily be by any one of a number of the societies which are deeply interested in the progress of technical education, new visual resources could be brought into being and extended into many new areas, to the benefit of all concerned.

THE T-SQUARE PAGE

Officers
JUSTUS RISING
J. L. HILL
J. L. HILL
F. A. HEACOCK
G. M. PHELPS

DEVOTED TO THE INTERESTS
OF ENGINEERING DRAWING

WILLIAM E. STREET, *Editor*
Agricultural and Mechanical College of Texas

Officers
F. M. PORTER
E. C. WILLEY
W. E. STREET
J. N. ARNOLD
J. M. WOOD
H. C. GRANT

In Memoriam

Thomas Ewing French

1871-1944

Enrollment of Undergraduate Civilian Engineering Students, 1944-45

Engineering Courses	Freshmen (1st year)		Sophomores (2nd year)		Juniors (3d year)		Seniors (4th year)		5th Year (of 5-yr. Curriculum)		Special Students		Evening Students		Totals		No. of First Degrees Conferred During the Academic Year 1943–44	
	M.*	W.†	M.	W.	M.	W.	M.	W.	M.	W.	M.	W.	M.	W.	M.	W.	M.	W.
Aeronautical	1,147	31	359	28	233	9	117	5	9	1	7	1	250	13	2,122	87	563	4
Agricultural	52	0	23	1	8	0	7	0	0	0	1	0	0	0	91	1	28	0
Architectural	301	50	92	53	62	22	44	6	7	5	10	4	19	0	535	140	81	5
Ceramic	44	9	33	4	18	4	11	0	0	0	0	67	0	0	106	84	63	0
Chemical	1,946	106	923	70	701	33	557	12	47	0	23	6	637	21	4,834	248	2,262	6
Civil	1,578	26	671	27	528	6	381	5	18	0	18	0	273	6	3,467	70	1,476	3
Electrical	2,483	40	1,064	37	740	19	553	9	21	0	26	2	920	20	5,807	127	2,043	4
General	1,254	25	482	7	266	7	112	0	0	0	5	0	314	18	2,433	57	341	0
Industrial	84	0	43	6	30	2	26	3	0	0	5	0	99	0	287	11	159	0
Mechanical	2,592	64	1,213	45	970	31	830	8	45	0	35	4	1,113	15	6,798	167	3,355	13
Metallurgical	80	2	57	1	99	1	74	0	0	0	5	0	150	3	465	7	393	0
Mining	91	2	32	0	43	0	47	1	0	0	8	0	0	0	221	3	152	1
Naval Arch. and Marine	16	0	20	0	56	0	6	0	0	0	0	0	0	0	98	0	44	0
Petroleum	225	4	76	1	31	0	31	0	0	0	7	1	0	0	370	6	89	0
Sanitary	8	0	6	0	9	1	4	0	0	0	3	1	0	0	30	2	11	0
Unclassified	6,610	217	565	30	135	11	142	6	47	0	107	8	1,814	103	9,420	374	56	3
Totals	18,511	576	5,659	310	3,929	146	2,942	55	194	6	260	93	5,589	199	37,084	1,385	11,116	39

* M. = Men. † W. = Women.

Enrollment of Undergraduate Civilian Engineering Students, 1944–45—Continued

Enrollment of Undergraduate Civilian Engineering Students, 1944-45—Continued

Engineering Courses	Freshmen (1st year)		Sophomores (2nd year)		Juniors (3d year)		Seniors (4th year)		5th Year (of 5-yr. Curriculum)		Special Students		Evening Students		Totals		No. of First Degrees Conferred During the Academic Year 1943-44	
	M.*	W.†	M.	W.	M.	W.	M.	W.	M.	W.	M.	W.	M.	W.	M.	W.	M.	W.
Akron	59	—	11	—	1	—	2	—	1	—	—	—	—	—	74	—	32	—
Ala. Poly	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—
Ala. Uni.	88	4	37	8	18	—	20	1	—	—	—	—	26	3	189	16	47	1
Alaska	7	1	2	—	2	—	—	1	—	—	5	—	—	—	16	2	2	—
Alfred	17	6	13	3	1	1	1	—	—	—	—	—	—	—	32	10	19	—
Arizona	67	3	22	5	16	1	8	1	—	—	10	—	—	—	122	10	18	—
Arkansas	83	3	22	—	13	—	11	—	—	—	—	—	—	—	129	3	30	—
Bradley	37	—	6	—	3	—	—	—	—	—	—	—	—	—	46	—	7	—
Brooklyn	218	—	29	—	33	—	23	—	—	—	2	—	800	46	1,105	46	182	—
Brown	46	—	12	—	8	—	4	—	—	—	—	—	—	—	70	—	—	—
Bucknell	18	2	5	—	5	2	5	—	—	—	—	—	—	—	33	4	23	2
Calif. Tech.	75	—	21	—	10	—	10	—	—	—	1	—	—	—	117	—	33	—
Calif. Uni.	126	4	34	3	41	0	47	1	—	—	—	—	—	—	248	8	126	1
Calif. Uni. So.	—	—	—	—	—	—	—	—	—	—	—	—	—	—	124	0	—	—
Calif. Uni. at L. A.	55	2	37	2	—	—	—	—	—	—	—	—	—	—	92	4	—	—
Carnegie	190	5	34	3	25	—	34	—	—	—	3	—	267	8	553	16	166	—
Case	163	1	31	—	51	3	29	—	—	—	16	1	373	34	663	39	307	—
Catholic	38	4	12	1	6	—	9	1	—	—	4	1	—	—	69	7	—	—
Cincinnati	195	38	56	24	43	—	9	—	20	—	5	—	912	—	1,240	62	114	—
Citadel	52	—	36	—	12	—	1	—	—	—	—	—	—	—	101	—	1	—
Clarkson	103	—	17	—	17	—	18	—	—	—	—	—	—	—	155	—	58	—
Clemson	380	—	53	—	22	—	16	—	—	—	—	—	—	—	471	—	—	—
Colo. Mines	67	—	22	—	14	—	16	—	—	—	—	—	—	—	119	—	51	—
Colo. A. & M.	20	1	3	—	6	—	4	—	—	—	—	—	—	—	33	1	24	—
Colo. Uni.	62	3	27	3	17	1	6	—	—	—	—	—	—	—	112	7	90	—
Columbia	119	—	36	1	35	2	20	2	—	—	4	—	—	—	214	5	33	—

* M. = Men. † W. = Women.

Enrollment of Undergraduate Civilian Engineering Students, 1944–45—Continued

Engineering Courses	Freshmen (1st year)		Sophomores (2nd year)		Juniors (3d year)		Seniors (4th year)		5th Year (of 5-yr. Curriculum)		Special Students		Evening Students		Totals		No. of First Degrees Conferred During the Academic Year 1943–44	
	M.*	W.†	M.	W.	M.	W.	M.	W.	M.	W.	M.	W.	M.	W.	M.	W.	M.	W.
Connecticut	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—
Cooper	55	2	40	1	20	2	18	2	17	—	—	—	253	7	403	14	127	—
Cornell	207	3	92	5	40	4	28	1	12	1	2	—	—	—	383	14	137	—
Dayton	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—
Delaware	19	—	8	—	4	1	8	—	—	—	—	—	—	—	39	1	19	—
Denver	70	4	7	2	4	1	2	—	—	—	—	—	—	—	83	7	11	—
Detroit	144	4	46	—	6	1	20	—	18	—	—	—	24	2	258	7	61	—
Drexel	240	9	73	5	21	—	30	—	5	—	8	3	—	—	377	17	114	—
Duke	55	1	11	2	8	—	8	—	—	—	—	—	—	—	82	3	33	—
Fenn	40	—	9	1	3	—	2	—	2	—	3	1	295	13	354	15	39	—
Florida	69	—	30	—	14	—	9	—	—	—	—	—	—	—	122	—	27	—
Geo. Wash.	100	9	53	4	24	1	23	—	—	—	—	—	—	—	200	14	—	—
Ga. Tech.	323	—	91	—	29	—	36	—	—	—	—	—	—	—	479	—	193	—
Harvard	—	—	2	—	4	—	6	—	2	—	—	—	—	—	14	—	43	—
Haverford	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—
Hawaii	64	1	27	1	20	—	2	—	—	—	32	—	—	—	145	2	4	0
Howard	47	1	8	—	6	1	6	—	—	—	—	—	6	2	73	4	3	—
Idaho	33	—	9	—	2	—	7	—	—	—	—	—	—	—	51	—	40	—
Ill. Tech.	268	4	64	2	72	2	66	1	—	—	27	5	612	5	1,109	19	296	—
Illinois Uni.	383	23	76	6	55	2	36	2	—	—	—	—	—	—	550	33	238	—
Iowa St. Coll.	131	8	60	6	27	2	37	—	—	—	2	—	—	—	257	16	105	1
Iowa Uni.	74	4	14	2	9	—	8	—	—	—	—	—	—	—	105	6	45	2
Johns Hopkins	77	3	23	—	11	—	8	—	—	—	3	—	222	2	346	5	109	—

* M. = Men. † W. = Women.

Enrollment of Undergraduate Civilian Engineering Students, 1944–45—Continued

Engineering Courses	Freshmen (1st year)		Sophomores (2nd year)		Juniors (3d year)		Seniors (4th year)		5th Year (of 5-yr. Curriculum)		Special Students		Evening Students		Totals		No. of First Degrees Conferred During the Academic Year 1943–44	
	M.*	W.†	M.	W.	M.	W.	M.	W.	M.	W.	M.	W.	M.	W.	M.	W.	M.	W.
Kansas St. Coll.	69	1	19	—	8	—	5	—	—	—	—	—	—	—	101	1	19	—
Kansas Uni.	124	3	49	1	24	1	19	—	—	—	—	—	—	—	216	5	49	—
Kentucky	124	1	49	1	24	—	19	—	—	—	—	—	—	—	216	2	49	—
Lafayette	124	—	49	—	24	—	19	—	—	—	—	—	—	—	216	—	49	—
Lehigh	124	—	49	—	24	—	19	—	—	—	—	—	—	—	216	—	49	—
Louisiana St.	124	—	49	—	24	—	19	—	—	—	—	—	—	—	216	—	49	—
Louisville	124	—	49	—	24	—	19	—	—	—	—	—	—	—	216	—	49	—
Lowell Tech.	124	—	49	—	24	—	19	—	—	—	—	—	—	—	216	—	49	—
Manhattan	124	—	49	—	24	—	19	—	—	—	—	—	—	—	216	—	49	—
Marquette	124	—	49	—	24	—	19	—	—	—	—	—	—	—	216	—	49	—
Maryland	124	—	49	—	24	—	19	—	—	—	—	—	—	—	216	—	49	—
Mass. Inst. Tech.	124	—	49	—	24	—	19	—	—	—	—	—	—	—	216	—	49	—
Michigan	124	—	49	—	24	—	19	—	—	—	—	—	—	—	216	—	49	—
Michigan St.	124	—	49	—	24	—	19	—	—	—	—	—	—	—	216	—	49	—
Minnesota	124	—	49	—	24	—	19	—	—	—	—	—	—	—	216	—	49	—
Mississippi St.	124	—	49	—	24	—	19	—	—	—	—	—	—	—	216	—	49	—
Missouri	124	—	49	—	24	—	19	—	—	—	—	—	—	—	216	—	49	—
Montana St.	124	—	49	—	24	—	19	—	—	—	—	—	—	—	216	—	49	—
Nebraska	124	—	49	—	24	—	19	—	—	—	—	—	—	—	216	—	49	—
New Hampshire	124	—	49	—	24	—	19	—	—	—	—	—	—	—	216	—	49	—
New Mexico	124	—	49	—	24	—	19	—	—	—	—	—	—	—	216	—	49	—
New York Uni.	124	—	49	—	24	—	19	—	—	—	—	—	—	—	216	—	49	—
North Carolina St.	124	—	49	—	24	—	19	—	—	—	—	—	—	—	216	—	49	—
North Dakota	124	—	49	—	24	—	19	—	—	—	—	—	—	—	216	—	49	—
Northeastern	124	—	49	—	24	—	19	—	—	—	—	—	—	—	216	—	49	—
Northwestern	124	—	49	—	24	—	19	—	—	—	—	—	—	—	216	—	49	—
Notre Dame	124	—	49	—	24	—	19	—	—	—	—	—	—	—	216	—	49	—
Ohio Northern	124	—	49	—	24	—	19	—	—	—	—	—	—	—	216	—	49	—
Ohio St.	124	—	49	—	24	—	19	—	—	—	—	—	—	—	216	—	49	—
Ohio Uni.	124	—	49	—	24	—	19	—	—	—	—	—	—	—	216	—	49	—
Oklahoma	124	—	49	—	24	—	19	—	—	—	—	—	—	—	216	—	49	—
Oklahoma A. & M.	124	—	49	—	24	—	19	—	—	—	—	—	—	—	216	—	49	—
Oregon St.	124	—	49	—	24	—	19	—	—	—	—	—	—	—	216	—	49	—
Penn. St.	124	—	49	—	24	—	19	—	—	—	—	—	—	—	216	—	49	—
Pittsburgh	124	—	49	—	24	—	19	—	—	—	—	—	—	—	216	—	49	—
Polytechnic Inst.	124	—	49	—	24	—	19	—	—	—	—	—	—	—	216	—	49	—
Princeton	124	—	49	—	24	—	19	—	—	—	—	—	—	—	216	—	49	—
Purdue	124	—	49	—	24	—	19	—	—	—	—	—	—	—	216	—	49	—
Rensselaer	124	—	49	—	24	—	19	—	—	—	—	—	—	—	216	—	49	—
Rice Inst.	124	—	49	—	24	—	19	—	—	—	—	—	—	—	216	—	49	—
Rose Poly.	124	—	49	—	24	—	19	—	—	—	—	—	—	—	216	—	49	—
Rutgers	124	—	49	—	24	—	19	—	—	—	—	—	—	—	216	—	49	—
St. Louis Uni.	124	—	49	—	24	—	19	—	—	—	—	—	—	—	216	—	49	—
San Jose St. Coll.	124	—	49	—	24	—	19	—	—	—	—	—	—	—	216	—	49	—
Santa Clara	124	—	49	—	24	—	19	—	—	—	—	—	—	—	216	—	49	—
South Dakota St.	124	—	49	—	24	—	19	—	—	—	—	—	—	—	216	—	49	—
South Dakota Uni.	124	—	49	—	24	—	19	—	—	—	—	—	—	—	216	—	49	—
Southern Cal.	124	—	49	—	24	—	19	—	—	—	—	—	—	—	216	—	49	—
Stanford	124	—	49	—	24	—	19	—	—	—	—	—	—	—	216	—	49	—
Stevens Inst.	124	—	49	—	24	—	19	—	—	—	—	—	—	—	216	—	49	—
Syracuse	124	—	49	—	24	—	19	—	—	—	—	—	—	—	216	—	49	—
Tennessee	124	—	49	—	24	—	19	—	—	—	—	—	—	—	216	—	49	—
Texas	124	—	49	—	24	—	19	—	—	—	—	—	—	—	216	—	49	—
Texas A. & M.	124	—	49	—	24	—	19	—	—	—	—	—	—	—	216	—	49	—
Tri-State	124	—	49	—	24	—	19	—	—	—	—	—	—	—	216	—	49	—
Tufts	124	—	49	—	24	—	19	—	—	—	—	—	—	—	216	—	49	—
Tulane	124	—	49	—	24	—	19	—	—	—	—	—	—	—	216	—	49	—
Utah	124	—	49	—	24	—	19	—	—	—	—	—	—	—	216	—	49	—
Vanderbilt	124	—	49	—	24	—	19	—	—	—	—	—	—	—	216	—	49	—
Villanova	124	—	49	—	24	—	19	—	—	—	—	—	—	—	216	—	49	—
Virginia	124	—	49	—	24	—	19	—	—	—	—	—	—	—	216	—	49	—
Virginia Mil. Inst.	124	—	49	—	24	—	19	—	—	—	—	—	—	—	216	—	49	—
Virginia Poly.	124	—	49	—	24	—	19	—	—	—	—	—	—	—	216	—	49	—
Washington St.	124	—	49	—	24	—	19	—	—	—	—	—	—	—	216	—	49	—
Washington Uni.	124	—	49	—	24	—	19	—	—	—	—	—	—	—	216	—	49	—
Wayne Uni.	124	—	49	—	24	—	19	—	—	—	—	—	—	—	216	—	49	—
West Virginia	124	—	49	—	24	—	19	—	—	—	—	—	—	—	216	—	49	—
Wisconsin	124	—	49	—	24	—	19	—	—	—	—	—	—	—	216	—	49	—
Worcester Poly.	124	—	49	—	24	—	19	—	—	—	—	—	—	—	216	—	49	—
Wyoming	124	—	49	—	24	—	19	—	—	—	—	—	—	—	216	—	49	—
Yale	124	—	49	—	24	—	19	—	—	—	—	—	—	—	216	—	49	—

* M. = Men. † W. = Women.

	77	3	23	—	11	—	8	—	—	—	3	—	222	2	346	5	109	—		

* M. = Men. † W. = Women.

Enrollment of Undergraduate Civilian Engineering Students, 1944–45—Continued

Engineering Courses	Freshmen (1st year)		Sophomores (2nd year)		Juniors (3d year)		Seniors (4th year)		5th Year (of 5-yr. Curriculum)		Special Students		Evening Students		Totals		No. of First Degrees Conferred During the Academic Year 1943–44	
	M.*	W.†	M.	W.	M.	W.	M.	W.	M.	W.	M.	W.	M.	W.	M.	W.	M.	W.
Kansas St. Coll.	82	2	21	1	13	—	8	—	—	—	3	—	—	—	127	3	93	—
Kansas Uni.	51	1	13	1	7	—	18	—	—	—	—	—	—	—	89	2	66	1
Kentucky	76	—	24	—	8	—	5	—	—	—	1	—	—	—	114	—	57	—
Lafayette	46	—	9	—	5	—	6	—	—	—	—	—	—	—	66	—	140	—
Lehigh	154	—	29	—	27	—	31	—	—	—	—	—	—	—	241	—	110	—
Louisiana	450	5	56	1	26	2	22	—	—	—	3	—	—	—	557	8	91	—
La. Poly.	64	2	22	—	1	—	7	—	—	—	—	1	—	—	94	3	39	0
La. So. W.	69	6	13	—	8	—	3	—	—	—	—	—	—	—	93	6	18	—
Louisville	31	—	12	—	16	3	7	—	—	—	3	—	—	—	69	3	57	2
Maine	83	7	26	5	5	—	16	—	—	—	6	—	—	—	136	12	80	2
Manhattan	138	—	29	—	30	—	11	—	—	—	—	—	—	—	208	—	41	—
Marquette	51	—	20	—	7	—	17	—	19	—	19	—	—	—	133	—	—	—
Maryland	106	2	29	1	22	—	10	—	1	—	4	—	20	—	192	3	37	1
Mass. Inst. Tech.	344	6	69	1	204	6	87	2	—	—	—	—	—	—	704	15	286	1
Mich. M. & T.	86	13	33	7	18	4	12	—	—	—	—	—	—	—	149	24	60	—
Mich. St. Coll.	18	—	35	4	18	—	16	—	—	—	—	—	—	—	87	4	66	—
Mich. Uni.	221	25	128	13	71	5	52	2	—	—	2	1	—	—	474	46	362	2
Minnesota	295	22	88	13	68	5	39	—	—	—	—	—	389	—	879	40	376	2
Miss. St. Coll.	135	1	22	1	1	—	2	—	—	—	—	—	—	—	160	2	—	—
Miss. Uni.	31	—	4	—	—	—	1	—	—	—	—	—	—	—	36	—	3	—
Mo. Mines	112	18	29	—	46	1	46	—	—	—	1	—	—	—	234	19	146	2
Missouri Uni.	80	2	26	—	5	1	8	2	—	—	—	—	—	—	119	5	70	—
Mont. Mines	10	—	4	—	14	—	7	—	—	—	1	—	—	—	36	—	6	—
Mont. St. Coll.	55	—	12	—	6	—	6	—	—	—	—	—	—	—	79	—	—	—
Nevada	33	—	4	—	8	—	3	—	—	—	7	—	—	—	55	—	36	—
Nebraska	186	3	12	—	16	—	14	—	—	—	1	—	—	—	229	3	74	—
Newark	170	10	41	2	41	3	31	1	—	—	—	—	88	—	371	16	84	—

* M. = Men. † W. = Women.

Enrollment of Undergraduate Civilian Engineering Students, 1944–45—Continued

Engineering Courses	Freshmen (1st year)		Sophomores (2nd year)		Juniors (3d year)		Seniors (4th year)		5th Year (of 5-yr. Curriculum)		Special Students		Evening Students		Totals		No. of First Degrees Conferred During the Academic Year 1943–44	
	M.*	W.†	M.	W.	M.	W.	M.	W.	M.	W.	M.	W.	M.	W.	M.	W.	M.	W.
New Hampshire	81	14	8	2	11	2	9	2	—	—	1	—	—	—	110	20	145	2
N. Mex. A. & M.	29	1	1	—	2	1	2	—	—	—	—	—	—	—	34	2	3	—
N. Mex. Mines	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—
N. Mex. Uni.	33	4	7	1	8	1	3	1	—	—	6	—	—	—	57	7	20	—
New York City Coll.	1,023	47	316	24	153	8	162	2	—	—	—	—	372	25	2,026	106	434	2
New York Uni.	293	—	108	—	70	—	18	—	—	—	16	1	442	21	947	22	237	—
N. Car. St. Coll.	399	3	84	—	28	—	21	—	—	—	—	9	—	—	532	12	76	—
N. Dak. St. Coll.	25	—	5	—	1	—	2	—	—	—	—	—	—	—	33	—	—	—
N. Dak. Uni.	21	2	3	—	—	—	3	—	—	—	—	67	—	—	27	69	22	—
Northeastern	426	9	117	5	29	—	55	—	44	—	5	—	—	—	676	14	137	—
Northwestern	133	3	48	2	33	1	—	—	—	—	1	—	—	—	215	6	80	—
Norwich	29	—	—	—	—	—	—	—	—	—	—	—	—	—	29	—	1	—
Notre Dame	112	—	26	—	11	—	10	—	—	—	—	—	—	—	159	—	102	—
Ohio No. Uni.	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—
Ohio St. Uni.	308	13	96	5	23	4	51	5	1	—	—	—	104	8	582	35	148	1
Ohio Uni.	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—
Okla. A. & M.	159	6	30	3	18	3	11	2	—	—	—	—	—	—	218	14	32	—
Okla. Uni.	181	9	36	6	9	2	3	1	—	—	—	—	—	—	229	18	—	—
Oregon	141	9	29	2	12	—	18	—	—	—	—	—	—	—	200	11	45	—
Pa. St. Coll.	245	10	77	8	47	5	41	2	—	—	—	—	—	—	410	25	320	—
Pennsylvania	77	—	34	—	12	—	19	—	—	—	—	—	—	—	142	—	106	—
Pittsburgh	99	4	46	4	26	2	33	1	—	—	6	—	173	7	383	18	193	—
Porto Rico	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—
Pratt	74	7	11	1	10	—	28	—	—	—	—	—	—	—	123	8	156	—
Princeton	60	—	6	—	11	—	12	—	—	—	—	—	—	—	99	—	113	—
Purdue	520	32	184	14	136	7	92	3	—	—	3	2	—	—	935	58	523	3

* M. = Men. † W. = Women.

Enrollment of Undergraduate Civilian Engineering Students, 1944–45—Continued

Enrollment of Undergraduate Civilian Engineering Students, 1944–45—Continued

Engineering Courses	Freshmen (1st year)		Sophomores (2nd year)		Juniors (3d year)		Seniors (4th year)		5th Year (of 5-yr. Curriculum)		Special Students		Evening Students		Totals		No. of First Degrees Conferred During the Academic Year 1943–44	
	M.*	W.†	M.	W.	M.	W.	M.	W.	M.	W.	M.	W.	M.	W.	M.	W.	M.	W.
U. S. Coast Guard	141	—	132	—	100	—	—	—	—	—	—	—	—	—	381	—	95	—
Union	43	—	15	—	5	—	5	—	—	—	2	—	—	—	70	—	—	—
Utah Ag.	14	1	4	—	4	—	2	—	—	—	—	—	—	—	24	1	—	—
Utah Uni.	119	5	50	3	11	—	14	—	—	—	—	—	—	—	194	8	83	—
Vanderbilt	71	1	19	1	9	—	10	1	—	—	3	—	—	—	112	3	—	—
Vermont	14	1	2	—	1	2	1	1	—	—	—	—	—	—	18	4	22	1
Villanova	46	—	4	—	12	—	11	—	—	—	—	—	—	—	73	—	74	—
Va. Mil.	141	—	15	—	26	—	3	—	—	—	—	—	—	—	185	—	5	—
Va. Poly.	224	1	70	5	28	2	32	1	—	—	2	—	—	—	356	9	158	—
Virginia	22	—	16	—	7	—	5	—	—	—	—	—	—	—	50	—	42	—
Wash. U. (St. Louis)	119	2	46	1	29	—	18	—	—	—	—	—	—	—	211	3	—	—
Wash. Uni.	114	4	19	1	20	1	32	1	—	—	—	—	—	—	185	7	63	—
Wash. St. Coll.	62	4	18	4	7	3	6	—	—	—	—	—	—	—	93	11	—	—
Wash. & Jeff.	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—
Wayne	84	7	13	3	4	2	10	1	—	—	4	—	111	10	226	23	28	—
Webb Inst.	All enlisted—assigned by Navy Department																	
W. Va. Uni.	89	3	24	3	19	—	9	1	—	—	3	—	—	—	141	7	59	—
Wisconsin	186	4	79	2	53	2	36	1	—	—	—	—	—	—	354	9	220	—
Worcester	78	—	36	—	17	—	11	—	—	—	—	—	—	—	142	—	113	—
Wyoming	72	3	16	3	4	—	3	—	—	—	2	—	—	—	97	6	—	—
Yale	115	—	18	—	16	—	12	—	—	—	2	—	—	—	163	—	164	—
Total U. S. Schools	17,262	561	4,909	294	3,077	136	2,320	53	142	1	254	93	5,589	199	33,555	1,337	10,576	36

* M. = Men. † W. = Women.

* M. = Men. † W. = Women.

Enrollment of Undergraduate Civilian Engineering Students, 1944–45—Continued

Canadian Schools

Engineering Courses	Freshmen (1st year)		Sophomores (2nd year)		Juniors (3d year)		Seniors (4th year)		5th Year (of 5-yr. Curriculum)		Special Students		Evening Students		Totals		No. of First Degrees Conferred During the Academic Year 1943–44	
	M.*	W.†	M.	W.	M.	W.	M.	W.	M.	W.	M.	W.	M.	W.	M.	W.	M.	W.
Alberta	136	1	61	—	90	1	50	—	—	—	6	—	—	—	343	2	47	—
Brit. Columbia	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—
Ecole Polytechnique	92	—	78	—	63	—	50	—	47	—	—	—	—	—	330	—	—	—
McGill	153	4	128	5	118	6	73	2	4	3	—	—	—	—	476	20	89	1
New Brunswick	60	—	43	1	34	—	29	—	—	—	—	—	—	—	166	1	18	—
Nova Scotia	—	—	—	—	46	—	33	—	—	—	—	—	—	—	79	—	33	—
Queen's	191	3	136	2	106	1	87	—	—	—	—	—	—	—	520	6	85	—
Saskatchewan	180	1	95	1	111	1	64	—	—	—	—	—	—	—	450	3	76	—
Toronto	437	6	209	7	284	1	234	—	1	2	—	—	—	—	1,165	16	201	2
Canadian	1,249	15	750	16	852	10	622	2	52	5	6	—	—	—	3,529	48	540	3
United States	17,262	561	4,909	294	3,077	136	2,320	53	142	1	254	93	5,589	199	33,555	1,337	10,576	36
Grand Total (145 inst.)	18,511	576	5,659	310	3,929	146	2,942	55	194	6	260	93	5,589	199	37,084	1,385	11,116	39

* M. = Men. † W. = Women.

Enrollment of Graduate Civilian Engineering Students, 1944-45

Engineering Courses	Enrollment in Work for the Master's Degree												Enrollment in Work for the Doctor's Degree											
	Full-Time Resident Students		Part-Time Resident Students		Evening Students		Others (Please name)		Total		Masters Degrees Conferred in 1943-44		Full-Time Resident Students		Part-Time Resident Students		Evening Students		Others (Please name)		Total		Doctors Degrees Conferred in 1943-44	
	M.*	W.†	M.	W.	M.	W.	M.	W.	M.	W.	M.	W.	M.	W.	M.	W.	M.	W.	M.	W.	M.	W.	M.	W.
Ala. Poly. Inst.	1	—	—	—	—	—	—	—	1	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—
Alabama Uni.	—	—	1	—	—	—	—	—	1	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—
Alfred	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—
Arizona	1	—	—	—	—	—	—	—	1	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—
Brooklyn	—	—	26	—	395	20	—	—	421	20	20	—	—	—	9	1	98	2	—	—	107	3	4	—
Brown	—	—	2	—	—	—	—	—	2	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—
Cal. Uni. So.	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—
Cal. Tech.	14	—	—	—	—	—	—	—	14	—	14	—	9	—	—	—	—	—	—	—	9	—	4	—
Cal. Uni.	14	—	—	—	—	—	2	—	16	—	9	—	3	—	—	—	—	—	—	—	3	—	2	—
Carnegie	3	—	—	—	63	—	—	—	66	—	7	—	—	—	2	—	—	—	—	—	2	—	2	—
Case	—	—	—	—	52	1	—	—	52	1	16	1	—	—	—	—	16	—	—	—	16	—	2	—
Catholic	—	—	2	—	—	—	—	—	2	—	—	—	—	—	1	—	—	—	—	—	1	—	—	—
Cincinnati	12	—	—	—	—	—	—	—	12	—	5	—	7	—	—	—	—	—	—	—	7	—	4	—
Colo. Mines	—	—	1	—	—	—	—	—	1	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—
Colo. Uni.	—	—	2	—	36	—	—	—	38	—	—	1	—	—	—	—	—	—	—	—	—	—	—	—
Columbia	4	—	52	—	—	—	—	—	56	—	5	—	3	—	2	—	7	—	—	—	12	—	2	—
Connecticut	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—
Cornell	—	—	21	—	—	—	—	—	21	—	6	—	—	—	13	—	—	—	—	—	13	—	2	—
Delaware	—	—	4	—	35	—	—	—	39	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—
Florida	5	—	2	—	—	—	—	—	7	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—
Ga. Tech.	—	—	3	—	—	—	—	—	3	—	2	—	—	—	—	—	—	—	—	—	—	—	—	—
Harvard	26	—	2	—	—	—	4	—	32	—	22	—	6	—	3	—	—	—	—	—	9	—	3	—

* M. — Men. † W. — Women.

Engineering Courses	Enrollment in Work for the Master's Degree												Enrollment in Work for the Doctor's Degree											
	Full-Time Resident Students		Part-Time Resident Students		Evening Students		Others (Please name)		Total		Masters Degrees Conferred in 1943–44		Full-Time Resident Students		Part-Time Resident Students		Evening Students		Others (Please name)		Total		Doctors Degrees Conferred in 1943–44	
	M.*	W.†	M.	W.	M.	W.	M.	W.	M.	W.	M.	W.	M.	W.	M.	W.	M.	W.	M.	W.	M.	W.	M.	W.
Idaho	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—
Ill. Tech	1	—	31	—	220	—	—	—	252	—	11	—	—	—	15	—	—	—	—	—	15	—	1	—
Illinois Uni	11	—	9	—	—	—	—	—	20	—	9	—	5	—	4	—	—	—	—	—	9	—	7	—
Iowa St. Coll	3	—	7	—	—	—	—	—	10	—	1	—	1	—	4	—	—	—	—	—	5	—	1	—
Iowa Uni	5	—	—	—	—	—	—	—	5	—	1	—	1	—	—	—	—	—	—	—	1	—	1	—
Johns Hopkins	—	—	4	—	15	—	—	—	19	—	1	—	—	—	11	—	—	—	—	—	11	—	3	—
Kans. St. Coll	—	—	3	—	—	—	—	—	3	—	1	—	—	—	—	—	—	—	—	—	—	—	—	—
Kansas Uni	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—
Kentucky	1	—	—	—	—	—	—	—	1	—	2	—	—	—	—	—	—	—	—	—	—	—	—	—
Lehigh	2	—	6	—	—	—	—	—	8	—	8	2	1	—	3	—	—	—	—	—	4	—	3	—
Louisiana	2	—	1	—	—	—	—	—	3	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—
Louisville	4	—	2	—	8	—	—	—	14	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—
Maine	2	—	—	—	—	—	—	—	2	—	1	—	—	—	—	—	—	—	—	—	—	—	—	—
Maryland	—	—	—	—	56	—	—	—	56	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—
Mass. Inst. Tech	143	3	—	—	—	—	—	—	143	3	135	2	65	4	—	—	—	—	—	—	65	4	18	—
Mich. St. Coll	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—
Mich. M. & T	1	—	—	—	—	—	—	—	1	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—
Mich. Uni	66	—	5	—	—	—	—	—	71	—	27	—	24	—	—	—	—	—	—	—	24	—	6	—
Minnesota	—	—	18	—	—	—	—	—	18	—	3	—	—	—	10	—	—	—	—	—	10	—	2	—
Mo. Mines	2	—	—	—	—	—	—	—	2	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—
Mo. Uni	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—
Mont. Mines	—	—	2	—	—	—	—	—	2	—	1	—	—	—	—	—	—	—	—	—	—	—	—	—
Nebraska	3	—	—	—	—	—	—	—	3	—	—	—	—	—	—	—	—	—	1	—	1	—	—	—
Newark	—	—	—	—	30	—	—	—	30	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—
New Hampshire	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—
N. Y. City Coll	2	—	—	—	14	2	—	—	16	2	1	—	—	—	—	—	—	—	—	—	—	—	—	—

* M. = Men. † W. = Women.

Enrollment of Graduate Civilian Engineering Students, 1944–45—Continued

Engineering Courses	Enrollment in Work for the Master's Degree												Enrollment in Work for the Doctor's Degree									
	Full-Time Resident Students		Part-Time Resident Students		Evening Students		Others (Please name)		Total		Masters Degrees Conferred in 1943–44		Full-Time Resident Students		Part-Time Resident Students		Evening Students		Others (Please name)		Total		Doctors Degrees Conferred in 1943–44	
	M.*	W.†	M.	W.	M.	W.	M.	W.	M.	W.	M.	W.	M.	W.	M.	W.	M.	W.	M.	W.	M.	W.	M.	W.
New York Uni.	1	—	—	—	181	2	—	—	182	2	53	—	2	—	—	—	13	—	—	—	15	—	1	—
N. C. St. Coll.	1	—	2	—	—	—	—	—	3	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—
Northwestern	—	—	4	—	36	—	—	—	40	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—
Notre Dame	2	—	—	—	—	—	—	—	2	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—
Ohio State	2	—	16	—	—	—	—	—	18	—	4	—	1	—	7	—	—	—	—	—	8	—	4	—
Okla. A. & M.	1	—	—	—	—	—	—	—	1	—	3	—	—	—	—	—	—	—	—	—	—	—	—	—
Okla. Uni.	4	—	—	—	—	—	—	—	4	—	2	—	—	—	—	—	—	—	—	—	—	—	—	—
Oregon	—	—	4	—	—	—	—	—	4	—	2	—	1	—	—	—	—	—	—	—	1	—	—	—
Pa. St. Coll.	2	—	20	—	—	—	—	—	22	—	5	—	—	—	4	—	—	—	—	—	4	—	—	—
Pennsylvania	—	—	17	—	75	—	9	—	101	—	11	—	—	—	4	—	—	—	—	—	4	—	2	—
Pittsburgh	—	—	—	—	304	—	—	—	304	—	32	—	—	—	—	—	—	—	—	—	—	—	1	—
Princeton	3	—	—	—	—	—	—	—	3	—	9	—	—	—	—	—	—	—	—	—	—	—	—	—
Purdue	4	—	16	1	—	—	—	—	20	1	7	—	—	—	13	—	—	—	2	—	15	—	4	—
Rensselaer	6	—	—	—	—	—	—	—	6	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—
Rochester	2	—	—	—	—	—	—	—	2	—	1	—	—	—	—	—	—	—	—	—	—	—	—	—
Rutgers	—	—	—	—	—	—	—	—	—	—	1	—	—	—	—	—	—	—	—	—	—	—	—	—
S. D. Mines	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—
Stanford	23	—	—	—	—	—	—	—	23	—	18	—	9	—	—	—	—	—	—	—	9	—	4	1
Stevens	—	—	—	—	310	13	—	—	310	13	39	—	—	—	—	—	—	—	—	—	—	—	—	—
Syracuse	5	—	—	—	—	—	—	—	5	—	1	—	1	—	—	—	—	—	—	—	1	—	—	—
Tennessee	2	—	3	—	—	—	—	—	5	—	1	—	—	—	—	—	—	—	—	—	—	—	—	—
Texas A. & M.	3	—	12	—	—	—	—	—	15	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—
Texas Tech.	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—
Texas Uni.	3	—	12	—	—	—	—	—	15	—	8	—	—	—	7	—	—	—	—	—	7	—	2	—
Thayer	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—
Tulsa	1	—	—	—	—	—	—	—	1	—	2	—	—	—	—	—	—	—	—	—	—	—	—	—

* M. = Men. † W. = Women.

Enrollment of Graduate Civilian Engineering Students, 1944–45—Continued

Enrollment in Work for the Master's Degree												Enrollment in Work for the Doctor's Degree											
Full-Time Resident Students		Part-Time Resident Students		Evening Students		Others (Please name)		Total		Masters Degrees Conferred in 1943–44		Full-Time Resident Students		Part-Time Resident Students		Evening Students		Others (Please name)		Total		Doctors Degrees Conferred in 1943–44	
M.	W.	M.	W.	M.	W.	M.	W.	M.	W.	M.	W.	M.	W.	M.	W.	M.	W.	M.	W.	M.	W.	M.	W.

Texas Uni.	3	—	12	—	—	—	—	—	15	—	8	—	—	—	7	—	—	—	—	—	7	—	2	—
Thayer	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—
Tulsa	1	—	—	—	—	—	—	—	1	—	2	—	—	—	—	—	—	—	—	—	—	—	—	—

* M. = Men. † W. = Women.

Enrollment of Graduate Civilian Engineering Students, 1944-45—Continued

Engineering Courses	Enrollment in Work for the Master's Degree												Enrollment in Work for the Doctor's Degree											
	Full-Time Resident Students		Part-Time Resident Students		Evening Students		Others (Please name)		Total		Masters Degrees Conferred in 1943–44		Full-Time Resident Students		Part-Time Resident Students		Evening Students		Others (Please name)		Total		Doctors Degrees Conferred in 1943–44	
	M.*	W.†	M.	W.	M.	W.	M.	W.	M.	W.	M.	W.	M.	W.	M.	W.	M.	W.	M.	W.	M.	W.	M.	W.
Utah Ag. Coll.	1	—	—	—	—	—	—	—	1	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—
Utah Uni.	3	—	—	—	—	—	—	—	3	—	2	—	—	—	—	—	—	—	—	—	—	—	—	—
Va. Poly	5	—	3	—	—	—	—	—	8	—	1	—	—	—	1	—	—	—	—	—	1	—	—	—
Va. Uni.	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—
Wash. St. Coll.	—	—	2	—	—	—	—	—	2	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—
Wash. Uni.	1	—	8	—	—	—	—	—	9	—	2	—	—	—	—	—	—	—	—	—	—	—	—	—
Wash. U. (St. Louis)	1	—	8	—	—	—	—	—	9	—	5	—	—	—	1	—	—	—	—	—	1	—	—	—
Wisconsin	3	—	—	—	—	—	—	—	3	—	1	—	—	—	3	—	—	—	—	—	3	—	3	—
Worcester	—	—	3	—	—	—	—	—	3	—	3	—	—	—	—	—	—	—	—	—	—	—	—	—
Wyoming	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—
Yale	2	—	—	—	—	—	—	—	2	—	15	—	4	—	—	—	—	—	2	—	6	—	3	—
Total U. S. Schools	411	3	336	1	1,831	38	14	—	2,666	42	525	4	143	4	118	1	144	2	5	—	410	7	93	1
Canadian Schools																								
Alberta	—	—	8	—	—	—	—	—	8	—	5	—	—	—	—	—	—	—	—	—	—	—	—	—
Brit. Columbia	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—
Ecole Polytechnique	—	—	1	—	—	—	—	—	1	—	4	—	—	—	1	—	—	—	—	—	1	—	—	—
McGill	2	—	1	—	—	—	1	—	4	—	1	—	—	—	—	—	—	—	—	—	—	—	—	—
New Brunswick	—	—	—	—	—	—	—	—	—	—	3	—	—	—	—	—	—	—	—	—	—	—	—	—
Queen's	4	—	—	—	—	—	—	—	4	—	2	—	—	—	—	—	—	—	—	—	—	—	—	—
Saskatchewan	—	—	4	—	—	—	—	—	4	—	1	—	—	—	—	—	—	—	—	—	—	—	—	—
Toronto	4	—	6	—	—	—	—	—	10	—	2	—	2	—	4	—	—	—	—	—	6	—	—	—
Total Canadian Schools	10	—	20	—	—	—	1	—	31	—	18	—	2	—	5	—	—	—	—	—	7	—	—	—
Total U. S. Schools	411	3	336	1	1,831	38	14	—	2,666	42	525	4	143	4	118	1	144	2	5	—	410	7	93	1
Grand Total (79 inst.)	421	3	356	1	1,831	38	15	—	2,697	42	543	4	145	4	123	1	144	2	5	—	417	7	93	1

* M. = Men. † W. = Women.

Comparative Enrollment of Undergraduate Civilian Engineering Students

Engineering Courses	1940–41* 155 institutions	1943–44* 151 institutions	1944–45* 145 institutions
Aeronautical	3,723	2,912	2,209
Agricultural	864	94	92
Architectural	1,119	393	675
Ceramic	730	159	190
Chemical	16,177	8,169	5,082
Civil	11,152	4,954	3,537
Electrical	15,505	7,599	5,934
General	——	1,967	2,490
Industrial	2,442	550	298
Mechanical	28,609	11,184	6,965
Metallurgical	2,276	879	472
Mining	2,294	365	224
Naval Arch. and Marine		497	98
Petroleum		424	376
Sanitary		27	32
Unclassified	25,727	9,214	9,794
Totals	110,618	49,436	38,468

Institution	1940–41	1943–44	1944–45
Akron	278	74	74
Alabama Poly. Inst.	1,278	478	279
Alabama Univ.	933	350	205
Alaska Univ.	122	11	18
Alfred Univ.	228	63	42
Arizona Univ.	383	116	132
Arkansas	332	——	132
Bradley Poly. Inst.	109	42	46
Brooklyn Poly. Inst.	1,872	1,469	1,151
Brown Univ.	171	240	70
Bucknell Univ.	261	98	37
Calif. Inst. Tech.	542	164	117
Calif. Univ.	1,876	461	252
Calif. Univ. at L. A.	000	000	96
Calif., Univ. of So.	756	357	124
Carnegie Inst. Tech.	2,010	809	569
Case School Appl. Sci.	1,706	884	702
Catholic Univ.	268	96	76
Cincinnati Univ.	1,601	460	1,302
Citadel	213	154	101
Clarkson Coll. Tech.	510	201	155
Clemson College	880	485	471
Colo. School Mines	773	213	119
Colo. State Coll.	294	55	34
Colorado Univ.	867	239	119
Columbia Univ.	585	271	219
Connecticut Univ.	230	160	
Cooper Union	1,340	544	417
Cornell Univ.	1,350	576	397
Dayton Univ.	316	70	——
Delaware Univ.	226	64	40
Denver Univ.	152	91	90
Detroit Univ.	856	336	265
Drexel Inst. Tech.	880	510	394
Duke Univ.	234	107	85
Fenn College	975	322	369
Florida Univ.	478	168	122
George Wash. Univ.	498	368	214
Georgia School Tech.	2,198	699	479

* Men and women.

Brooklyn Poly. Inst.	1,872	1,469	1,151	Georgia School Tech.	2,198	699	479

* Men and women.

Comparative Enrollment of Undergraduate Civilian Engineering Students—Continued

Institution	1940–41	1943–44	1944–45	Institution	1940–41	1943–44	1944–45
Harvard Univ.	110	41	14	Mont. Sch. Mines	475	29	36
Haverford College	——	12		Mont. St. College	290	95	79
Hawaii Univ.	132	121	147				
Howard Univ.	54	72	73	Nevada Univ.	221	39	33
				Nebraska Univ.	781	288	232
Idaho Univ.	409	116	51	Newark College Eng.	705	564	387
Illinois Inst. Tech.	4,087	1,679	1,128	New Hampshire Univ.	390	138	130
Illinois Univ.	2,290	597	583	N. Mex. A. & M. Coll.	182	22	36
Iowa State College	1,956	701	273	N. Mex. Sch. Mines	141	14	
Iowa State Univ.	480	145	111	New Mexico Univ.	251	78	64
				New York City Coll.	3,278	2,927	2,132
Johns Hopkins Univ.	1,696	535	351	New York Univ.	2,193	1,114	969
				No. Car. State Coll.	1,322	724	544
Kansas State College	1,047	258	130	No. Dak. State Coll.	326	66	33
Kansas Univ.	649	274	91	No. Dak. Univ.	272	50	96
Kentucky Univ.	429	107	114	Northwestern Univ.	1,483	1,199	690
				Northwestern Univ.	398	367	221
Lafayette College	332	146	66	Norwich Univ.	228	——	29
Lehigh Univ.	1,040	403	241	Notre Dame Univ.	529	270	159
La. Poly. Inst.	——	194	97				
La. So. W. Univ.	236	129	99	Ohio No. Univ.	157	29	
Louisiana Univ.	1,179	405	565	Ohio State Univ.	1,800	703	617
Louisville Univ.	324	164	72	Ohio Univ.	242	——	
				Oklahoma A. & M. Coll.	1,220	201	232
Maine Univ.	611	224	148	Oklahoma Univ.	1,551	319	247
Manhattan College	307	187	208	Oregon State Coll.	961	216	211
Marquette Univ.	613	254	133				
Maryland Univ.	597	292	195	Pa. State College	1,718	742	435
Mass. Inst. Tech.	2,050	1,052	719	Pennsylvnia Univ.	434	150	179
Mich. Coll. M. & T.	772	127	173	Pittsburgh Univ.	1,285	334	401
Mich. St. College	958	276	91	Porto Rico Univ.	313	——	
Michigan Univ.	2,052	770	520	Pratt Institute	558	261	131
Minnesota Univ.	2,091	1,349	919	Princeton Univ.	404	173	99
Miss. St. College	639	210	162	Purdue Univ.	3,487	1,125	993
Mississippi Univ.	71	32	36				
Missouri Sch. Mines	870	424	253	Rensselaer Poly. Inst.	1,260	497	319
Missouri Univ.	622	204	224	Rhode Island St. Coll.	321	90	70

Comparative Enrollment of Undergraduate Civilian Engineering Students—Continued

Institution	1940–41	1943–44	1944–45
Rice Inst.	534	179	139
Rochester Univ.	172	68	46
Rose Poly. Inst.	283	98	89
Rutgers Univ.	250	178	122
Santa Clara Univ.	82	37	43
So. Car. Univ.	204	78	75
So. Dak. St. Coll.	230	55	32
So. Dak. Sch. Mines	311	141	49
Southern Methodist Univ.	196	122	62
Stanford Univ.	417	—	134
Stevens Inst. Tech.	620	281	672
Swarthmore College	73	57	29
Syracuse Univ.	438	278	196
Tennessee Univ.	738	240	197
Tenn. Poly. Inst.	178	41	37
Texas A. & I.	197	—	
Texas A. & M.	3,101	1,202	1,238
Texas Mines	—	—	
Texas Tech. College	739	357	300
Texas Univ.	1,476	846	690
Thayer School Eng.	23	32	5
Toledo Univ.	584	236	226
Tufts College	394	154	69
Tulane Univ.	371	242	206
Tulsa Univ.	214	146	135
U. S. Coast Guard Acad.	261	356	381
Union College	164	75	70
Utah Agr. College	212	46	25
Utah Univ.	515	429	202
Vanderbilt Univ.	232	117	115
Vermont Univ.	133	37	22
Villanova	242	174	73
Va. Mil. Inst.	361	119	186
Va. Poly. Inst.	1,695	522	365
Virginia Univ.	249	97	50
Washington Uni. (St. Louis)	377	262	214
Washington Univ.	1,444	317	192
Wash. State Coll.	629	124	104
Wash. & Jeff. College	—	79	
Wayne Univ.	655	236	249
Webb. Inst.	63	6	—
West Virginia Univ.	508	185	148
Wisconsin Univ.	1,472	612	363
Worcester Poly. Inst.	605	291	142
Wyoming Univ.	359	84	103
Yale Univ.	239	108	163
Total	108,759	45,381	34,894

Canadian Schools

Institution	1940–41	1943–44	1944–45
Alberta Univ.	299	307	343
British Columbia Univ.	—	738	
Ecole Polytechnique	293	313	330
McGill Univ.	—	455	496
New Brunswick Univ.	—	—	166
Nova Scotia College	57	69	79
Queen's Univ.	588	541	526
Saskatchewan Univ.	470	490	453
Toronto Univ.	—	1,119	1,181
Canadian	1,707	4,032	3,574
United States	108,759	45,381	34,894
	110,466	49,413	38,468

Villanova	242	174	73				
Va. Mil. Inst.	381	112	186		110,466	40,413	38,408